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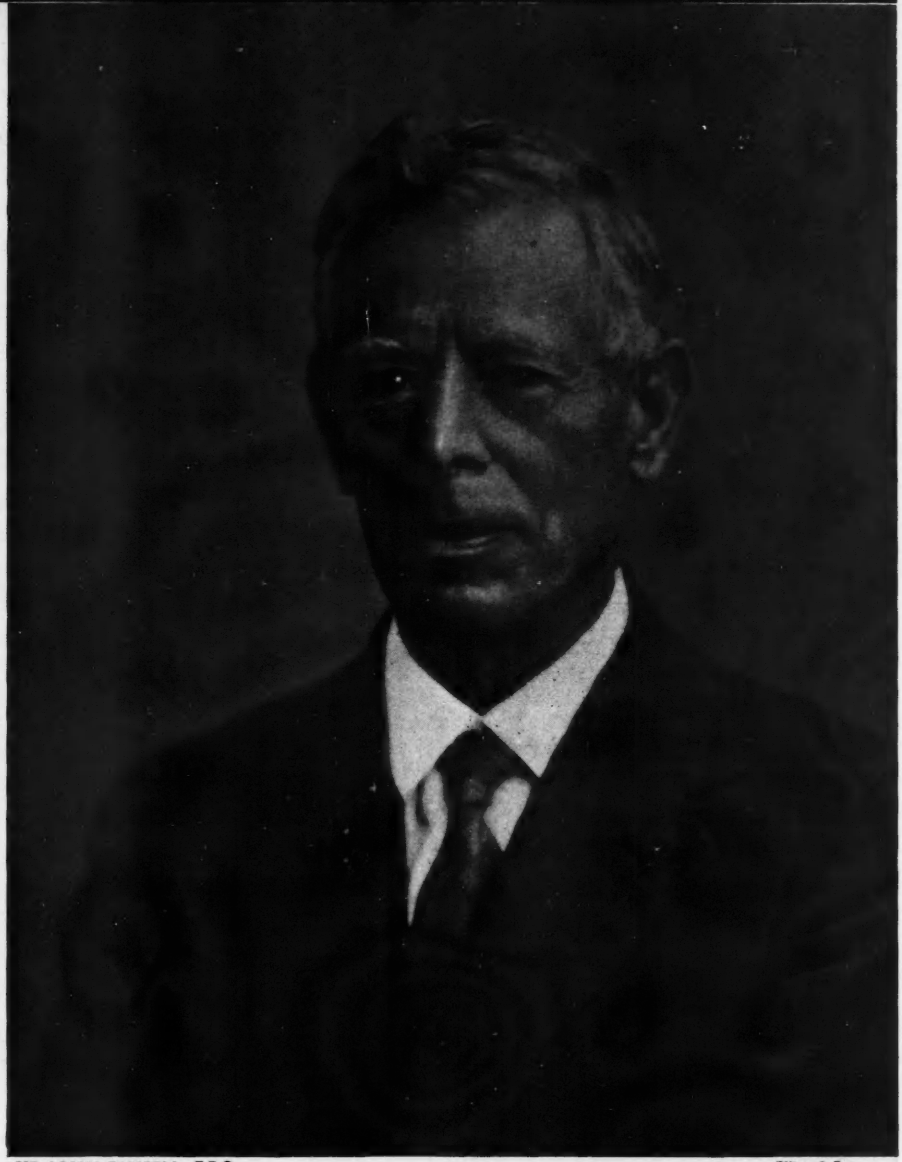

SIR JOHN RUSSELL, F.R.S. Elliott & Fry

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THE MAGAZINE OF SCIENTIFIC PROGRESS

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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

The Training of Physicists

A REPORT has recently been produced on The Education and Training of Physicists by a Committee appointed by the Institute of Physics. It is a progressive document which sets out in a concise form many of the reforms in scientific education which have been suggested by individuals in the past, or which have been brought about by the war.

It is most welcome that the Institute should set the seal of its approval on the retention after the war of the State Bursar system as a substitute for the previous, much narrower, system of University Scholarships. In laying down the principle that "Entrance to a University should depend on the ability of the student to profit by the course and not merely on success in a competitive examination", the Institute has lent the weight of its authority to a much-needed reform of our educational system, a reform which forms an integral part of the process of democratisation of British education. Formerly wealth, or great ability combined with good luck, were the passports to our Universities. The war has driven home the lesson that such criteria of entry do not secure for the community the best scientific brains which we can produce, and renders it a matter of urgency that entrance to our Universities should be governed by an equitable system of the kind proposed.

A welcome corollary is the recommendation that no student should be required to pledge himself to a particular career as a condition for receiving support during a University course. This condition has applied in the past especially to the teaching profession, which cannot be said to have gained by the compulsory inclusion within its ranks either of individuals whose tastes have radically changed between the ages of 18 and 21, or of those who have entered teachers' training courses solely as a means of obtaining a University education. The extension of this principle to other academic subjects will, it is to be hoped, take the sting out of the ancient gibe, "Those who can, do; those who can't, teach", and will ensure that the teaching profession shall consist exclusively of those who feel a vocation for it, freed from the encumbering presence of those who merely drifted into it.

The terms of reference of the report are confined to the problems of the Training of Physicists, and thus the report does not touch very closely on the problems of the scientific training of general pupils, nor does it deal with the training of teachers of physics. It emphasises that "in the post School Certificate years the school curriculum should not be biased to meet any special requirements of those boys and girls who may proceed later to a University or Technical College". This is a welcome measure, since it will preserve for the physicists a breadth of education which is needed if they are to make the best possible use of their technical instruction, but it does leave a number of problems unsolved. The danger is not so much that the *physicists* will receive insufficient general education, but that the other pupils may receive a scientific training as a part of their general education which is suited only to those pupils who are most likely to become specialists in physics. This is a very real difficulty, a discussion of which would lead far beyond the scope of the Institute's report. By confining its discussion to the post School Certificate stage this particular difficulty has to some extent been by-passed, but at the same time the report recommends the postponement of specialisation, a change which is likely to raise this particular difficulty in a form more acute than that which obtains now. One way out is hinted at in the report's remarks on General Education in Science, where it is stated that "The student's introduction to physics is only too often formal and unattractive, a state of affairs for which the nature of our present examinations may be partly responsible", and continuing "The elements of physics can be presented in such a way as to make a very strong appeal to most pupils if more use is made of their natural interest in everyday objects".

The sections devoted to University Courses begin with a recommendation that at least three years' attendance should be necessary for the award of a first degree, a most welcome statement if it is to be interpreted in the sense

that an extension of the existing course is desirable. Under a State Bursar scheme there would seem to be no obstacle to such an extension, and further evidence for the interpretation of the report in this sense is provided by the collateral suggestion that a general course in science should normally be the prelude to entering the Honours School of Physics. For the student proposing to make research work his profession it would then follow that in order to reach existing standards in his speciality, further time over and above three years would be required.

Paragraph 14 sketches out proposals which will, in effect, improve the liaison between the Universities and Industry or Government service. They include suggestions for training in various practical specialities such as high-vacuum technique, glass technology, and others.

Roughly speaking the effect of these reforms would be to make the earlier stages of University scientific education much broader, and the later stages more highly specialised and deliberately directed towards a realistic vocational training for the particular branch of physics which the student intends to enter.

This recommendation is backed up by the proposal that the Institute itself should undertake the establishment of suitable courses in these technical subjects for students of physics.

The two remaining topics which are discussed are the function of Technical Colleges and the contact of physics students with industry. As to the former, the report suggests that it should not be the function of Technical Colleges to provide training for External Degrees at Universities, and it expects that with the development of the State Bursar scheme this function will recede into the background. It also recommends the extension of facilities for the continuation of education at Technical High Schools into full-time or part-time courses at Technical Colleges, and suggests the provision of courses on the lines of those for National Certificates and Diplomas in branches of technical physics, the latter to be included within the framework of these certificates and diplomas.

The sections dealing with these points would have gained in value if the principle had been adopted of affording, especially to those who had entered scientific employment with low qualifications, real and ample opportunity for transference to the more highly qualified grades as distinct from the possibility of the improvement of qualifications within a grade. There are at present many workers in laboratories employed as technical assistants whose scientific knowledge is very considerable, but at the moment barriers exist which render it extremely difficult for all but the very persistent and determined to obtain qualifications which would transfer them to the highly qualified grades. In this way a considerable amount of scientific ability is denied its full expression; nor will the problem be solved by the provision of a State Bursar scheme only for school-leaving candidates. There will always be men and women whose scientific abilities develop late, and who, unless assistance on an adequate scale is provided, will not be able to make the transition from the grade of technical assistant to the research grades. A clear statement of principle here would have given great support to the conception of the scientific profession as a unity, with a genuine equality of opportunity for all the mutually dependent grades of workers within it.

The plea for greater contact with industry requires no elaboration. It is one which has frequently been made and which is implicit in the whole formulation of this report. Such close contact is of inestimable value to both partners, as has been demonstrated by the experience of both the U.S.A. and the U.S.S.R. The detailed working-out of such schemes is a very considerable undertaking, and the report rightly does not attempt to do more than sketch some of the possibilities.

Although the report deals specifically with physicists, there is little in it which could not be applied without change to other sciences, and the Institute is to be congratulated on the production of so important a document. It is confidently to be expected that the report will receive general support from other scientific bodies, some of which, such as the British Association and the Association of Scientific Workers, have been moving along very similar lines.

Lavoisier

On August 26th, 1743, Antoine Laurent Lavoisier, one of the greatest scientists France has ever produced, was born in Paris. He studied at the College Mazarin and took his Baccalaureat and Licenciat in law, but at the same time he was studying an extraordinary variety of sciences under some of the best teachers in France. From an early age he undertook systematic meteorological observations, which he continued without interruption almost to the end of his life. He was a serious young man who at 19 deliberately put aside frivolous pursuits, and who at 20 was associating with distinguished scientists.

He fell under the influence particularly of Guettard, who was devoting himself to the preparation of geological maps of France, and young Lavoisier spent three years helping in the collection of geological data in the provinces near Paris. This led to the publication of his first scientific paper, a discussion of the various varieties of gypsum (plaster of Paris) which was read to the Academy of Sciences on February 25th, 1765.

More notable, however, was his performance in a prize essay competition on street lighting, for which he was awarded a special gold medal for his discussion of the scientific principles involved. By this time Guettard's project of a geological atlas of France had received official recognition, and Lavoisier again assisted him, travelling with him widely, and meeting many of the most distinguished of contemporary European scientists. In the course of this work Lavoisier performed prodigious labours, which included the taking and the analysis of thousands of samples of water. He was not however to receive due credit for his work, for Guettard retired, and Monnet, the inspector-general of mines, went on to produce an incomplete version of the atlas which was ascribed only to himself and Guettard, without mention of Lavoisier.

This piece of plagiarism did not occur until 1780, by which time Lavoisier had already been elected to the French Academy under somewhat curious circumstances. In 1768 Lavoisier was recommended to the King for election by the Academy, but for various political reasons

it was thought desirable that the metallurgist Jars should be elected to the vacant place. However, a way out was found by electing Jars as an *associé* and creating a special place as an *adjoint* for Lavoisier, within the curious hierarchy of divisions of membership of which the Academy was then composed.

Lavoisier retained his association with the Academy until the Revolution, and during that time drew up an extraordinary variety of scientific reports dealing with all sorts of topics from the engraving of coats of arms and the making of tapestry to the siting of slaughter houses and the adulteration of cider. Several of the topics obviously proceed directly from his early work with Guettard, for they include a discussion of the water supply of Paris, tables of specific gravities and a memoir on hydrometers.

In the same year as his election to the Academy, Lavoisier entered the *Ferme*, an association of financiers which every six years bought the right of tax collection from the Government. He travelled widely in the course of this work, continuing his observations and becoming familiar with the condition of the people of France, but it was his well-known association with this monopoly which was to be one of the causes which brought him into disfavour with the makers of the French Revolution.

That, however, was to be long in the future, and in the meanwhile he married the daughter of the head of the tax-farming syndicate, Marie Anne Pierrette Paulze. She was only fourteen years old at the time, and the marriage seems to have been arranged to rescue her from the clutches of an influential uncle who wished his niece to make a political match. Strange to say the marriage was very happy, and the young wife was a great help to Lavoisier both in the laboratory and in the translation into French of foreign scientific memoirs.

At the time of his marriage Lavoisier became controller of the supply of gunpowder to the French army, but he found himself faced with enormous difficulties as the result of the method by which the powder was manufactured.

Like tax farming, gunpowder manufacture was a monopoly carrying with it certain privileges, such as the right to dig for saltpetre anywhere, and also the right to be bought off any particular digging proposal. The manufacture was artificially restricted, and the industry was riddled with corruption. By various administrative reforms Lavoisier was able to increase production enormously and to improve the quality of the powder, one method being the offer of prizes by the Academy for improvements in saltpetre manufacture.

His residence at the Arsenal became a centre for scientific discussion and he was visited there by many famous men, including the English chemist Joseph Priestley. During this time he continued his association with the *Ferme*, and although he made certain progressive changes, such as the abolition of certain discriminatory taxes against Jews, he became violently unpopular for his project of building a wall round Paris to prevent smuggling. His unpopularity was increased in 1789, when the removal of a large quantity of inferior powder and its replacement by a better grade made him the object of general suspicion and accusations of treachery.

These two episodes were the means of his downfall, for although the *Ferme* was suppressed in 1791 and Lavoisier subsequently rendered great service to the Revolutionary War by the excellent supplies of gunpowder and his work on the Treasury Commission, he was imprisoned along with the other directors in 1793 when they were accused of malpractice. He was brought before the Revolutionary Tribunal in 1794 and executed on May 8th of that year. His widow subsequently married again, her second husband being another scientist, Count Rumford, but the marriage was not happy and the pair separated.

One is driven to the view of Lavoisier as a kind-hearted man involved in politics, but having little understanding of the inevitable historical development through which France was passing.

His fame rests, however, not on his political work but on his contributions to the fundamentals of chemistry, and in particular on his dethronement of the phlogiston theory which had dominated chemistry for a century or more. This was based on the idea that when substances were burned, something—namely phlogiston—was removed from them. Lavoisier, perhaps from his experience as Secretary and Treasurer of the Commission on Weights and Measures, applied exact measurement to these ideas, and found that when sulphur and phosphorus are burned they undergo an increase in weight. We now know that this is due not to the removal of phlogiston, but to the addition by chemical combination of oxygen. Lavoisier established this fact in a memoir published in 1782 but written five years earlier in which he describes "dephlogisticated air", which he named "oxygen" or acid-producer, in the erroneous belief that all acids were formed by the union of oxygen and simple non-metallic substances.

Lavoisier did much for the development of the modern concept of an element, and for the view that solid, liquid and gas are simply three modes of matter. We must honour Lavoisier for the essential part which he played in the development of chemistry into an exact science, and can only lament the fate which caused him to be associated with some of the most repressive features of the old regime. Under happier circumstances he might have found new scope for his genius and energy in the regime which welcomed and honoured Franklin and other men of science.

Astronomical Milestones

A GREAT part of modern astronomy is concerned with the physical properties of the stars—their sizes, their masses and temperatures, and the ways in which they are maintained as going concerns. Very little of this information can be obtained directly; but by the application to the stars of physical laws which have been verified in the laboratory, and by inference from one type of star to another, a great body of knowledge has been acquired by roundabout and indirect methods. One type of star which has played a very large part in this process is the family known as the Cepheid variables, a new theory of which has recently been advanced by Dr. F. Hoyle and Dr. R. A. Lyttelton.

This is the latest chapter in a story which began in the autumn of 1784, when two English astronomers, Pigott and Goodricke, were searching for stars whose brightness was variable. Two of the three stars whose variability

they discovered belong to the family of Cepheids, and one of them, δ Cephei, has given the name to the whole family.

The brightness of Cephei varies very regularly over a range of just under two to one, taking about five days and nine hours for each cycle of variation. Like all Cepheids, its rise in brightness is very much more rapid than the decline, although the lengths of the periods of known Cepheids range all the way from a fraction of a day to 120 days or even more. In 1895 it was announced that Cepheids with short periods had been discovered in a number of the globular clusters of stars which surround our own galaxy. Since that time Cepheids have been discovered not only in our own galaxy but in the distant nebulae as well, until to-day there are some 1,500 short period Cepheids known, of which 600 are found in globular clusters. In addition, about 2,500 long period Cepheids have been discovered in the Magellanic Clouds, which are large star clusters forming appendages to our own galaxy. Very many more have been found in external galaxies, for they are very bright stars which can be observed even at very great astronomical distances.

The most rapidly varying Cepheid known is a faint star CY Aquarii which can be observed with a three inch refracting telescope or a five inch reflector. So rapid is its variation that its brightness increases by two and a half times in less than an hour and a half.

The real importance of these stars as an aid to the progress of astronomy did not become apparent until 1912 when Miss Henrietta Leavitt made a study of 25 Cepheids which had been discovered in the smaller Magellanic Cloud. Their periods ranged from 2 to 120 days, and Miss Leavitt discovered that when the stars were arranged in the order of increasing period they were also in order of increasing brightness, so that period and brightness went hand in hand. Thus those which went through their cycle in two days appeared just over a million times as faint as Vega, while those which varied in 120 days appeared sixteen times brighter than the two-day Cepheids. Now the apparent brightness of a star is determined both by its real or intrinsic brightness and by its distance. A star may appear bright either because it is exceptionally luminous or because it is very near to us. The importance of Miss Leavitt's discovery was that all the stars she observed belonged to the same cluster and were hence all at roughly the same distance, so that their apparent brightness was an indication as to how bright they really were.

Her work showed that there was a relation between the brightness and the period of a Cepheid, so that once a star has been recognised as a Cepheid a knowledge of its period tells us how bright the star really is, and hence how far off it must be to appear as faint as it does. In this way Cepheids have come to act as astronomical milestones for determining distances, and because of their wide distribution they have proved extraordinarily valuable for this purpose.

Naturally there have been attempts to account for this striking behaviour of Cepheids, and a theory was developed by Professor Harlow Shapley and Sir Arthur Eddington which accounted for it as a pulsation of the star. It was thought that Cepheids first collapsed under the action of gravity, and were then blown out again by the heat which the contraction produced. This theory met with some difficulties, one of which was that the variation in brightness and the expansion and contraction of the stars (which can be detected in other ways) were not in step.

The new theory of Hoyle and Lyttelton supposes that a Cepheid is not a single star, but two stars which revolve round one another under the action of their mutual gravitational attraction. However, the two stars cannot be detected separately because it is further supposed that they are surrounded with an extensive envelope or atmosphere of hot gas. A study of such systems has shown that if the atmosphere is fairly tenuous and the stars are very bright and of roughly equal mass, then this atmosphere will not rotate with the stars. What does happen however is that each part of the surface bulges out in turn as a result of the rotation of the central pair of stars. On the pulsation theory the whole surface of the star moves out simultaneously. On this theory the surface is only extended in one direction at any one time, but the bulge moves regularly round the surface much as a wave moves over the surface of water. Further calculation shows that this elongated mass of gas does not radiate uniformly in all directions, and so, to the terrestrial observer, there will be a waxing and waning of light as the more and less luminous parts of the surface come into his field of view. The situation is rather like a flashing lighthouse whose light blazes up for a few moments when the beam crosses our field of vision.

By means of this theory the authors have been able to explain a number of puzzling features of the light curves of Cepheids, but a further interesting development is the way in which they have tried to link up Cepheids with another unusual type of star—the novae. A nova (see Discovery for February 1943) is a star which undergoes a sudden catastrophic increase in brightness. Hoyle and Lyttelton have supposed that a Cepheid can pass into a nova in the following way. For various reasons it is possible that the two stars which they suppose form the centre of the Cepheid may approach one another and eventually coalesce. This causes a great disturbance of the system, which may lead to the ejection of matter and the exposure of regions of the star at very high temperatures—up to a million degrees or more. If this happened there would be a sudden increase in brightness and the star would present all the appearance of a nova.

It remains to be seen whether this theory will stand the test of criticism, but whether it will do so or not it is very interesting, if only because it is the first attempt to provide a definite link between the Cepheids and the Novae.

M. DAVIDSON.

Milk from all angles

EARLY in July an important meeting of the Nutrition Society was held to discuss problems connected with the production and distribution of milk. The discussion was most thorough and the importance of the varied aspects was stressed by Professor H. D. Kay, who said "The future of national nutrition is bound up with milk production, and milk production is bound up with British farming." After these opening words it was appropriate that the first paper should concern the economic and agricultural aspects of milk production, a subject which was

dealt with (unofficially) by Mr. J. L. Davies, the milk production officer of the Ministry of Agriculture. He had some critical things to say about the organisation of British dairy farming and drew particular attention to the difficulties which arise from the organisation in very small units of a great industry employing 300,000 people and a capital of something like £350,000,000.

Over a third of the dairy herds contain less than 10 cows, and only one in twenty-five more than 50. Many of the 150,000 farms involved are small and need extensive improvements if they are to become producers of high-quality clean milk. Not less than £100,000,000 will have to be spent to do this. A further difficulty is that because the production units are so small the cowmen have to work a seven-day week to give the cows the necessary daily attention, whereas larger units could arrange staggered working with a six-day working week. The breeding of cows needs attention, for many of them produce only about half as much milk as they ought to, and this can only be brought about by improvements in breeding. A cow which is a poor milker requires a proportionately greater expenditure per gallon of milk to keep her alive. Mr. Davies also discussed marketing, and urged that milk supplies to large towns should be pasteurised.

This problem of making milk safe and clean was discussed by other speakers too. Dr. Wooldridge said that 50% of our farms were not suitable for the production of milk, and Professor Ashby pointed out that diseases of cows add 25% to the economic cost of every gallon of milk.

Dr. Mattick dealt with the same topic from the bacteriologist's point of view. For all communities with a population of 20,000 or more pasteurisation should be obligatory, and this should be extended as soon as possible to rural areas. Pasteurisation can eliminate milk-borne diseases, among which, according to Professor Wilson, must be included tuberculosis, diphtheria, typhoid, paratyphoid, dysentry and food poisoning. Infected milk causes between 1,500 and 2,000 deaths each year from tuberculosis, and it is believed that several hundred cases of undulent fever are due to the same cause. He too was an advocate of pasteurisation; and in view of the statements which have been made on the effect of pasteurisation on the nutritional value of milk, it was interesting to have the statement of Dr. Kon of the National Institute for Research in Dairying, who pointed out that such effects were only very slight and could be regarded as negligible.

In view of the unanimity of this meeting in favour of pasteurisation it is interesting to look at the proposals contained in the Government White Paper on the Nation's Milk Supply which was published in July.

Here, too, there is an emphasis on the importance of good-grade animals and a realisation that they must be improved. The measures proposed for the better control of cattle disease consist in much more frequent inspection of herds, a task which it is estimated will involve about 30,000 additional inspectors for the country as a whole. The proposals for improving the standard of production on the farms consist mainly in greater supervision and co-operation between the veterinary experts and the farmers. A welcome proposal is to transfer the supervising authority entirely to the Ministry of Agriculture and Fisheries. At present this body is responsible for the health of the animals, whereas the local sanitary authorities and the County Councils are concerned with the conditions under which the milk is produced. The change will therefore replace a multitude of local authorities by a single central authority. While this will undoubtedly lead to improvements, it does not seem probable that a satisfactory state of affairs can be produced unless the capital for wholesale reconstruction of farms can be produced, a step which, in any case, can hardly be taken until after the war. The new scheme envisaged for the regulation of milk production will have the effect of producing a better collaboration between the farmers and the Ministry's Veterinary Staff, who will be able to provide the necessary advice and guidance on the spot.

Of more immediate interest are the steps which it is proposed shall be taken to improve the distribution of milk of good quality. It is implied by the White Paper that there has been some dissatisfaction with the results of the new scheme for zoning the distribution of milk. The fact that many people now have a milkman who is not their own choice needs the corollary of a definite guaranteed standard of milk wherever it is obtained. It is therefore proposed that the Minister of Food shall have powers to schedule areas in which the milk sold must be either heat treated (a term which includes pasteurisation) or must be T.T. or Accredited Milk. The latter term implies a degree of supervision of the herd and the milk produced rather less rigorous than is prescribed for T.T. Milk. While encouraging pasteurisation as much as possible, it is evidently considered to be more practicable to foster the production of T.T. milk rather than pasteurised. To this end certain administrative reforms are proposed in connection with the payment to the producer and by the consumer for this milk. As the White Paper remarks "The present arrangements are designed to encourage production of this valuable type of milk, but they do not encourage its purchase as such by the consumer." The result of the present system of the present system is that very often T.T. milk is bulked with ordinary milk, thereby destroying its special value. The new arrangements will provide for the sale of T.T. milk at a much smaller premium over ordinary milk.

While the reforms envisaged are doubtless valuable it seems likely that they will be the subject of considerable controversy, and that in some quarters it will be considered that they do not go far enough.

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Sir John Russell, F.R.S.

DIRECTOR OF ROTHAMSTED FOR 31 YEARS

THE speed with which the wounds of Europe heal after the Nazis have been driven out of the occupied countries must to a large extent depend on the skill with which the Allied Post-War Requirements Bureau, set up in the winter of 1941-42, has budgeted for the material needs that must be satisfied during the "first-aid" period and the early stages of reconstruction. One of the most important committees connected with this bureau is the Technical Advisory Committee on Agriculture. The choice of Sir John Russell as its chairman was the natural one. His name must have leapt to many minds as the organisation of the bureau and its committees began to take shape, for only a few months before Sir John had given the first clear lead on the subject of relief measures for Europe's devastated farmlands, speaking with great eloquence at the World Order Conference of the British Association on the steps which could be taken to make good the agricultural stocks then being ruthlessly destroyed as the Russians put into effect their military measure of "scorched earth." Sir John finds the time not only to preside over this committee and to carry out his responsibilities as director of one of the world's largest agricultural research stations, but also to act as adviser to the Soviet Relations branch of the Ministry of Information. The first three days of every week he spends at M.O.I. and the rest of the time — including his Sundays—he devotes to Rothamsted. In the last war he was equally busy. He was already head of Rothamsted, and in addition he served on the Munitions Inventions Panel and acted as technical adviser on soils and fertilisers to Sir Thomas Middleton's Food Production Department, set up to make good the food lost to the U-boats.

Early Days

Sir John's career, which has brought him fame in the sphere of agriculture, might well have developed very differently. For he was trained not as an agricultural scientist but as a chemist. He had left school at fourteen to work in a shop in London. During that time he attended evening classes at the City of London College and the People's Palace (now Queen Mary's College). Then he decided he wanted to be a clergyman like his father, and it was while he was studying for the ministry at the Carmarthen Presbyterian College that the principal recommended that he should take up science. Thus it was that his father started him at the University College of Wales at Aberystwyth, and from there Russell won a scholarship to Victoria University (which is now merged into Manchester University). After graduation he stayed on as lecturer and demonstrator in chemistry. It was his activities outside college that led him indirectly to become interested in farming.

Like other members of the staff he used to spend many of his leisure hours as a social worker among the slum dwellers of Manchester. His contact with these people brought him to the conclusion that one remedy for the squalid conditions of city life might lie in "the back to the land" movement. The more backstreets he visited the more often he thought of the country and of farming, so that it came as no surprise to his friends when he took the first opportunity of transferring to scientific work at an agricultural centre. He became assistant, in the chemistry department of Wye Agricultural College, to Sir Daniel Hall, who coupled chemistry teaching with the principalship of that very fine training centre which he had helped to establish. When Hall left to take charge of Rothamsted in 1901, Russell succeeded him as head of the chemistry department, where he combined tutorial work with research into such things as soil sterilisation (his discoveries in this subject laid the foundation of the technique now widely adopted in greenhouse practice) and trying to find a method of soil classification that would be useful to the farmer.

Meantime Hall was setting about his new job with a will, dusting off the cobwebs and making plans that were to enable Rothamsted to hold the lead in agricultural research which it was then in danger of losing. For twenty years little research had been done there, and indeed the centre's only living claim to fame at that time was that the field experiments started by Lawes and Gilbert were still maintained. As Sir Daniel Hall wrote "My heart sank when I came to take possession of the laboratory . . . it was more like a museum . . ." Yet within a few years, using the money that the Goldsmiths Company and the late Mr. James Mason had given, Hall had started a new research laboratory. He staffed it with four scientists; first a woman botanist, Dr. Winifred Brenchley, who is still hard at work in Rothamsted's botany department, which she directs; a bacteriologist, Dr. H. B. Hutchinson; an organic chemist, W. A. Davies; and E. J. Russell. Into the fabric of agricultural research began to be woven new threads from sciences other than chemistry, which up till then had seemed to be almost the only science with a direct bearing on the improvement of crop yields.

Agricultural science was still very much the Cinderella of British science. The first real fillip it was to receive came, a few years after Hall and Russell had gone to Rothamsted, when Lloyd George set up the Development Fund with the aim of rehabilitating British farming. Unfortunately, though the station benefited from this step, which brought almost the first official support which research in agriculture had received, it lost in another direction, for Sir Daniel Hall left Rothamsted on being appointed one of the commissioners responsible for administering the Development Fund. In the years Russell and Hall were together they produced one classic book—*Soils and Agriculture of Kent, Surrey and Sussex*, the first important soil survey to be published in Britain, and one of the first in the whole world. The second fillip to agricultural research was given by the World Great War, which proved to the ordinary farmer, if not to the whole country, the vital need for scientific method

to shape farming practice, so that the farming community made the repeal of the Corn Production Act after the Armistice conditional upon £1,000,000 being set aside to finance research.

Sir John as Director

Rothamsted, in company with other centres, now had less difficulty than ever before in finding money to maintain and to expand its activities. Russell, who had succeeded Hall as director, was able to begin assembling a team of scientific workers who were to increase the renown of Rothamsted. The experiments already completed had yielded useful results in plenty, and valuable conclusions had been derived from these by the application of elementary methods such as "the five-year averages" which Hall had used. But Sir John realised that to extract the maximum from all the data collected a statistician was needed, a specialist skilled in the new techniques which had recently been introduced into the compilation of the national census, and trained in the latest methods of sampling and statistical analysis. He was most fortunate in his choice, for the statistician he added to the staff was none other than R. A. Fisher, the greatest name in biological statistics to-day. To Rothamsted from Bradfield College, where he was a mathematics master, Fisher brought his shrewd talents and applied them with great originality, devising such useful novelties as the "Latin square" and the "randomised blocks" which put the field experiments on a new and altogether sounder basis.

Russell considered it was time too that more attention was given to the micro-organisms of the soil. The bacteria, it is true, were already being investigated at Rothamsted, but there were such beasts as the soil protozoa demanding investigation, since it seemed likely that they might influence soil fertility by devouring the useful bacteria. So from Manchester University Sir John acquired the services of the late Ward Cutler, whose great skill in this branch of zoology was later to be lent to the D.S.I.R., when it was endeavouring to discover ways of dealing with sewage and the effluents from sugar beet and milk factories. Another thread was woven into the variegated fabric with the development of the science of soil physics; Dr. B. A. Keen joined the staff, and so became the first British expert on that branch of agricultural science. (It is interesting that Sir John's son, Dr. E. W. Russell, is a soil physicist; his investigations have given us a clearer conception of how soil particles aggregate into "crumbs," the physical units determining the condition which the farmer calls "tilth.")

When he retires at the end of September Sir John will be able to look back over a life of notable accomplishment. He has contributed to the sum of knowledge not only by his own researches, but by having built a wonderful research team, which, because it is a team, has been able to discover facts and solve problems which few, if any, scientists working individually would have been able to unravel. When he went to Rothamsted the staff consisted of only five scientists; when he hands over to Dr. W. G. Ogg the reins he has held for 31 years, he will be leaving behind a team of well over fifty members.

Sir John was married in 1903. He has two daughters, and of his three sons, two are now dead.

The Last Train from Warsaw

Outside Rothamsted Sir John indulges a keen interest in foreign lands and their languages. His travels have taken him four times to Russia, and to America, India and Africa —each visit being something of a busman's holiday. One African trip took him over 3,000 miles up the Nile, and one of his ambitions, as yet unfulfilled, is to re-trace the steps which Stanley took on his west-to-east journey across Africa.

Sir John's keeness for travel nearly cost us his services during this war. In August 1939, on his way back from Russia, he was staying in a remote Polish village, and was blissfully unaware of the news that Hitler was massing troops on the frontier. Had it not been for a batch of lantern slides which he wanted for a lecture he was giving on his return he might have spent the duration in an internment camp, instead of helping to plan the future of Europe's post-war agriculture from London. The friends he was staying with asked him to remain a little longer, saying he could get his slides made in the Polish capital. Fortunately he adherred to his original plans, which took him across the frontier just in time, the train he caught being the last to leave Warsaw. His other, more tranquil, relaxations are walking and gardening; on the latter he considers himself a happy amateur.

I should like to mention Sir John's post bag. In addition to the many official letters he receives and his correspondence with his host of scientific friends he receives hundreds of letters from young men in the Forces who want advice on how to start themselves in farming after the war. With that kindliness which is so characteristic, he answers every one of those letters personally.

WILLIAM E. DICK

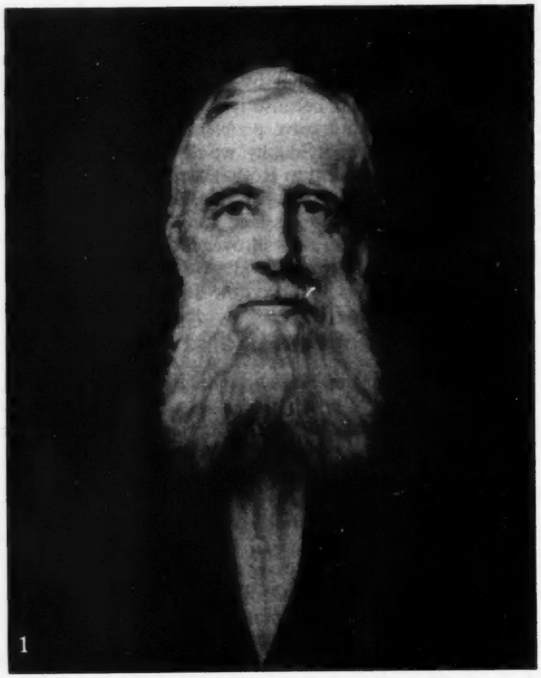
The Place of Science in Soviet Industry

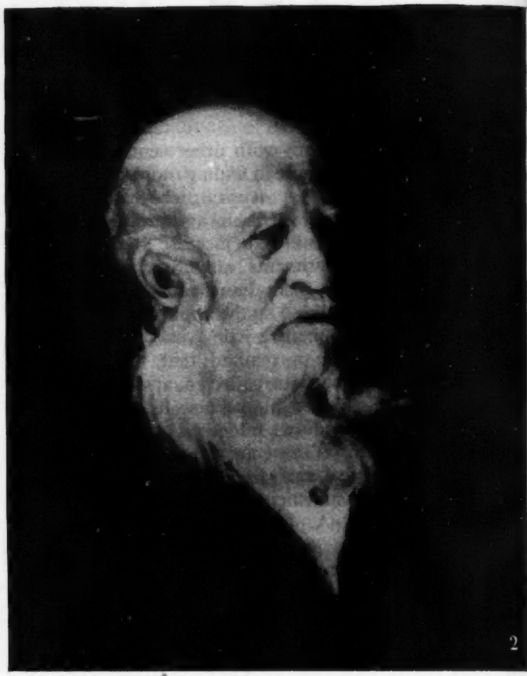
THE Soviet Government recently awarded Orders and medals to scientific workers of the Institute of Physical Problems of the Academy of Sciences of the U.S.S.R. for a new method of obtaining liquid air and liquid hydrogen.

The Director of the Institute, Peter Kapitza, a Member of the Academy of Sciences and Fellow of Royal Society (London), was awarded the Order of Lenin. At a meeting held at the Institute in celebration of the awards, Kapitza delivered a speech which is given here in abridged form.

"In our Soviet country distinctions and honours are awarded for work of benefit to the State, hence awards conferred on us have particular significance, for they are an expression of recognition of the work done by our Institute. A noteworthy thing about our work is that it didn't begin as an inventive idea developed along purely engineering lines, but sprang from an idea for providing the country with cheap oxygen. As the Institute before that had been engaged on problems of refrigeration, and conducted its researches to the lowest point of freezing, namely the liquefaction of helium, the broad scientific analysis of the conditions of obtaining liquid oxygen proved well within its powers.

"The path of research which I, as the Director of the Institute, choose was to concentrate all its available forces on the solution of one problem—to focus all its resources on one point. As Commander-in-chief of our small research army, I concentrated on one problem and pursued it until it was solved. There are men in our industry who are always interested in innovations, and we were able to enlist their collaboration and enthusiasm. Thanks to this collaboration, we arrived at an installation for obtaining liquid oxygen, which has now been put into operation."





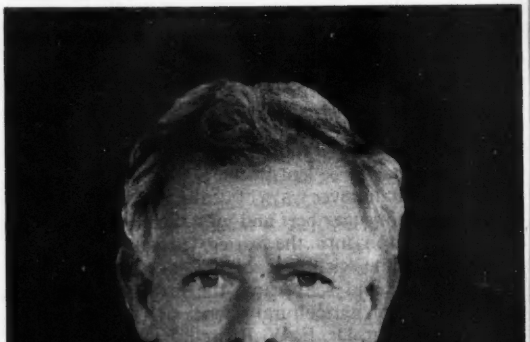


FIG. 1.—Sir John Bennet Lawes, Bart., D.C.L., LL.D., F.R.S., founder of Rothamsted (*from a portrait by Herkomer*). FIG. 2.—Sir Joseph Henry Gilbert, M.A., Ph.D., LL.D., F.R.S., first chemist of Rothamsted (*from a portrait by F. O. Salisbury*). FIG. 3.—Sir Alfred Daniel Hall, K.C.B., D.Sc., F.R.S., Director of Rothamsted, 1902-1912. FIG. 4.—Sir E. John Russell, D.Sc., F.R.S., Director of Rothamsted since 1912

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FIG. 5.—Interior of the barn, which was the first laboratory at Rothamsted

Rothamsted: 1843–1943

D. J. WATSON, M.A., Ph.D.

On 1 June, 1843, a young chemist, Joseph Henry Gilbert, took up an appointment as assistant to John Bennet Lawes in the agricultural investigations which Lawes was conducting on his estate at Rothamsted, near Harpenden in Hertfordshire. This date marked the beginning of a partnership which lasted for fifty-seven years, until the death of Lawes in 1900, and from which the Rothamsted Experimental Station eventually developed.

For several years before 1843 Lawes had been experimenting on the effect of various chemical substances on plant growth. He had found that superphosphate of lime, made by treating ground bones with sulphuric acid so as to render the phosphate in them soluble in water, had a very beneficial effect on turnips. In 1842 he took out a patent for manufacturing this material, set up a factory, and began to advertise his products in the Press. From this small beginning, an industry has developed which now has an annual world output of 15,000,000 tons.

Lawes did not lose his interest in the problems of plant growth when he became a manufacturer, but continued his experiments; and with the advent of Gilbert the scope of the work was extended. The temperaments of the two men were remarkably complementary. Lawes had a fertile imagination, which constantly suggested new subjects for investigation, and a broad, practical outlook; but he had neither the patience nor the time to devote himself to detailed, orderly research, for he had many other interests outside the experiments. Gilbert, on the other hand, had been trained in the discipline of science; he was extremely methodical and had a passion for accuracy and detail; he was just as interested in the sometimes tedious routine of carrying through an enquiry to completion, as in the final results.

The experiments which they began were stimulated by a controversy with Liebig, who in 1840 had stated his views on plant nutrition in a report to the British Association. He maintained that the nitrogen which plants contain was derived mainly from ammonia in the atmosphere; consequently it was unnecessary to supply nitrogen to the soil in the form of manure. The other mineral substances, notably phosphate, potassium, sodium, magnesium, calcium and silica, which were found when the ash of plants was analysed, were taken up from the soil, and only these needed to be supplied as fertilizers. Lawes

Copyright : Rothamsted Experimental Station

FIG. 6.—Physics laboratory in the new wing, Rothamsted

disagreed with this, for all his earlier experiments and his farming experience convinced him that a supply of nitrogen from the soil was necessary for crop growth, and that the yield of the crop depended more on this than on the supply of ash constituents.

Field Experiments

Lawes and Gilbert therefore set up a series of field experiments in which they measured the effect on the yield of various crops of supplying mineral salts containing the elements found in the plant ash, without or with ammonia salts or nitrate at varying rates. In most of the experiments the crops were grown continuously on the same land, which received the same fertilizer treatment year after year, but in one experiment the crops were grown in rotation as in normal practice. The continuous cropping was adopted as a simple way of repeating the experiments, and after a few seasons, the value of nitrogenous fertilizers was fully demonstrated.

The experiments were not abandoned at this point, but were continued in order to provide information on the effects of seasonal weather conditions on yield, and of the exhaustion of the soil on the plots where certain nutrients were withheld. The supervision of these experiments occupied Gilbert for the rest of his life. The source and fate of the nitrogen in plants continued to be his main interest. In an attempt to make a balance sheet for the nitrogen cycle, long series of analyses of the crops, of the soil, of the drainage waters from the soil, and of rainwater were made. For the latter purpose, large gauges to measure rainfall and drainage were built. The records from these gauges and from other meteorological instruments installed later have been continued up to the present time; they have provided invaluable information for the study of the effect of weather factors on crop yield. The possibility of the fixation of atmospheric nitrogen was considered, but appeared to be ruled out by a series of experiments carried out in 1857-58 in association with an American worker, Evan Pugh. It was not until 1886, when Hellriegel and Wilfarth demonstrated the fixation of nitrogen in the root nodules of leguminous plants, that the whole subject was cleared up, and it was realised that the peas, beans, and clover, tested in the Rothamsted experiments, together with several non-legumes, had been grown in such carefully controlled conditions that infection with the nodule organism *Bacillus radicicola* had been prevented, so that no nitrogen fixation could take place. Another aspect of the nitrogen story was opened up in 1877, when Warington came to work at Rothamsted, and demonstrated the conversion of ammonia in the soil into nitrate by bacterial action.

Animal Feeding

Lawes and Gilbert also made experiments on the feeding of farm animals, to find out the value of the different constituents of the food stuffs. They were able to show

FIG. 7.—Aerial photograph of the Barnfield experiment on mangolds, started by Lawes and Gilbert in 1876, and still continued. The four small white rectangles in the left-hand bottom corner of the picture are the rainfall and drainage gauges which Lawes and Gilbert built

that much of the fat laid down in a fattening animal came from carbohydrate in the food, a matter which had previously been the subject of much controversy. Once again they came into conflict with Liebig, who had expressed the view that the nitrogenous constituents of the food were the source of energy for work performed by the animals, so that the work done could be estimated by the amount of nitrogen excreted in the urine. Lawes and Gilbert's experiments showed, on the contrary, that fat and carbohydrate were the main energy sources, and that nitrogen excretion by the animal depended on the quantity given in the diet. Still pursuing the nitrogen theme, they endeavoured to construct balance sheets between the nitrogen in the food, and that assimilated in the animals' tissues or excreted, but they were never able to account satisfactorily for all the nitrogen intake; this was not achieved until much later when experimental and analytical methods had been greatly improved. The practical importance of this question lies in the dependence of the manurial value of the animals' excreta on the composition of the food which they consume. Lawes devoted much attention to this problem, with the particular object of assessing the compensation to be paid to an outgoing tenant for the unexhausted manurial value of the foodstuffs consumed during his tenancy. One other practical result of the animal experiments was that Lawes and Gilbert were able to construct tables relating the amount of food consumed to the increase in weight of the fattening animals, which laid the foundation for much future work on animal nutrition.

Sufficient has been said to show the breadth of the field covered by the Rothamsted investigations during Lawes' and Gilbert's lifetime, but the account of the subjects investigated is far from exhaustive. A glance through the list of 169 papers published up to 1900 shows such diverse titles as the "Utilisation of Town Sewage", "Amount of Water given off by Plants during their Growth", "Selection of Artificial Manures for the Sugar Cane", "Letter on Bread Reform" and "Chemistry of Fairy Rings". Many of these papers, especially those written by Lawes, dealt with general questions which were the subject of contemporary interest and debate. In discussing such matters Lawes based his arguments on the results of the Rothamsted experiments, and this backing of established fact gave his contributions great authority.

Plant Nutrition

The most important part of Lawes' and Gilbert's researches, and the subject with which their names are especially associated, was the investigation of plant nutrition; their results laid the foundations of the modern practice of manuring crops. The characteristic feature which distinguished their methods from those of other

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FIG. 8.—Part of a modern field experiment on barley. Note the small size of the plots compared with those in FIG. 7. The two plots in the foreground illustrate Lawes' and Gilbert's first important discovery, of the importance of nitrogenous fertilizers in determining crop growth. The plot on the left received a dressing of sulphate of ammonia; that on the right did not

workers, was that their experiments were made on field crops growing in conditions which, except for the restrictions imposed by experimental requirements, closely matched those of practical agriculture. The field experiments were the focal point of all the Rothamsted investigations. Their uninterrupted continuation, and the astonishing completeness of the records, was the outstanding achievement of Gilbert. Several of the experiments are still carried on, unchanged so far as is possible. One of them, the famous Broadbalk experiment, is now producing its hundredth successive wheat crop. Some of the plots in this experiment have had the same treatment every year since 1843; on most of the others the treatments have been given continuously since 1852, when the experiment was redesigned and established in its present form.

The value of Lawes' and Gilbert's work was fully recognised during their lifetime; both received knighthoods and many other honours. As early as 1853, a subscription list was opened by Hertfordshire farmers to present Lawes with a testimonial. The money was devoted to the building of a new laboratory to replace the old barn which had been used previously. Lawes continued to bear the whole cost of the experiments, and in 1889 set up a Trust with an endowment of £100,000 to ensure their future continuation. The Lawes Agricultural Trust and its management Committee are still the governing body of Rothamsted, but the activities of the Station have expanded so greatly that the original endowment has long been inadequate to meet the cost of the work, which is now largely sustained by grants from the Ministry of Agriculture and from other sources.

Sir Daniel Hall as Director

Lawes died in 1900, and Gilbert in 1901. They were succeeded in the direction of the Station by A. D. Hall. Hall faced a difficult task, for in the later years of Lawes' and Gilbert's time, the period of active development had come to an end; the field experiments continued according to a settled routine, carried along by the momentum of the activity of earlier years, but no fresh ground was broken. As Hall said, the laboratory had become more like a

museum than a laboratory. Agriculture was in a very depressed state, and there was little interest in or support for agricultural research. Hall did not open up fresh fields of enquiry, but sought to infuse new life into the study of the old problems by bringing in biological workers to a field which previously had been regarded as a branch of chemistry. Additional financial support was secured when the Development Fund for the rehabilitation of British farming was set up in 1911. For the first time public funds were available for the financing of research on agricultural problems. The Development Commission, of which Hall was a member, set up several institutes each to deal with one branch of agricultural research, and Rothamsted was made responsible for research on soil and on plant nutrition. The laboratories were extended, and arrangements were made whereby the facilities for field work were improved. Eventually Hall's work for the Commission absorbed the whole of his time, and in 1912 he gave up the directorship of Rothamsted, to be succeeded by Dr. (now Sir) E. J. Russell.

Under Sir John Russell's Direction

This, the third phase of the development of Rothamsted, began with a twofold programme of research on fundamental scientific rather than immediately practical problems. It was intended to investigate, firstly, the soil conditions which affect the growth of crops, and secondly the changes which variations in these conditions induce in the plant. A start was made with the first part, and investigations were undertaken on the supply of nutrients and water from the soil, and on the soil atmosphere and temperature. The staff continued to grow and a new laboratory, still in use though much altered, was erected in 1914. The steady progress of this work was interrupted by the outbreak of war, when other problems of immediate urgency, arising from the campaign for increased home food production, had to be tackled. The difficulties encountered in war-time expansion of agriculture led to a more general appreciation of the necessity for research. In the post-war years Rothamsted grew steadily, and its field of activity was enlarged by the establishment of departments of Entomology, Plant Pathology, Insecticides and Statistics, in addition to the older Chemistry, Physics, Botany, and Bacteriology departments. The taking over of the Woburn Experimental Station, previously run by the Royal Agricultural Society, gave facilities for field work on a light sandy soil, for contrast with the heavy clay loam of Rothamsted. The location of the Imperial Bureau of Soil Science at Rothamsted strengthened the association with agricultural research in the Dominions and Colonies, which developed from the movement of members of the staff to posts throughout the Empire, from the frequent visits of dominion and colonial research workers, and from direct collaboration in research between institutes overseas and Rothamsted.

The subjects of enquiry in the different departments, during the years between the wars, are too numerous to list, but one development should be mentioned because of its particular association with Rothamsted. The formation of the Statistical Department has been perhaps the most fruitful of all Sir John Russell's innovations. Sir John was very anxious that as much information as possible should be extracted from the long records of the classical field experiments, so carefully kept by Gilbert. He realised that previous attempts to analyse them were hampered by the crudity of the methods used, and in 1919 appointed R. A. Fisher as statistician to devise new methods and apply them to the vast mass of data which had accumulated. In this Fisher was very successful, and went on to develop a new technique of experimental design, backed by appropriate statistical theory, which has revolutionised field experimentation and found application in many other branches of science.

This year will see the completion of the first hundred years of agricultural research at Rothamsted, but it will also be memorable in Rothamsted's history for another reason. Sir John Russell, who has directed the Station for nearly one third of its existence, is to retire. Sir John has been able to bring about many great improvements in the equipment of the Station during his directorship. The purchase of the experimental farm in 1934 was a characteristic example of his ability to overcome difficulties and turn them to advantage. The farm had previously been held on lease, and the tenure was anything but secure. Some of the land was held on a yearly tenancy, and some at even shorter notice. In face of an imminent threat that the land might be sold for building development, Sir John succeeded in raising by public subscription, in eight weeks, the purchase price of £35,000. Not content with his past achievements, Sir John had determined that he would leave the station well prepared for future developments by equipping it with the best possible buildings and apparatus. The outbreak of war has prevented the completion of his plans, but it was found possible to finish the erection and equipment of a new laboratory wing and a range of glass-houses, to re-furnish some of the old laboratories, and to extend the farm buildings. Without these additions much of the work now in progress on urgent war problems could not have been undertaken.

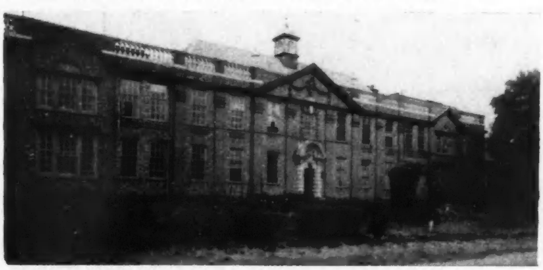
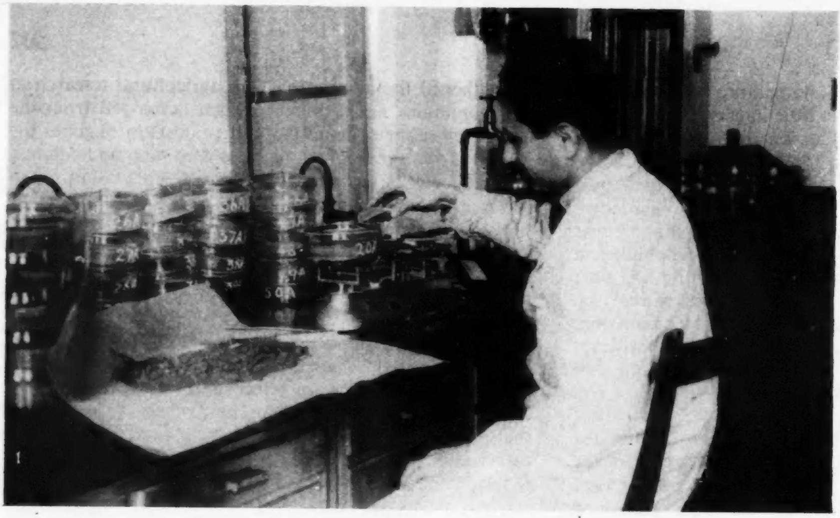
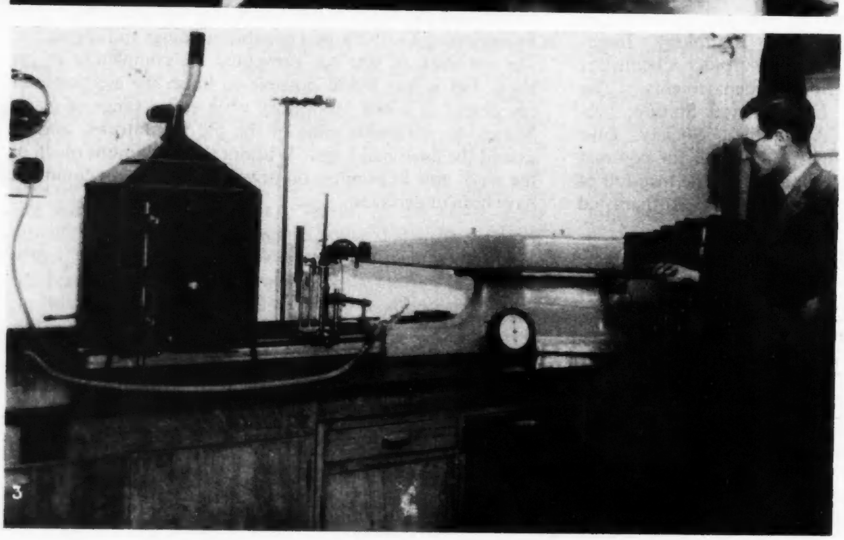


FIG. 9.—Rothamsted headquarters and laboratories

RESEARCH AT





Rothamsted's centenary celebrations took the form of a conducted tour round the station and a luncheon, at which the guests included the Minister of Agriculture and representatives of 28 nations. Congratulatory cables to the station came from many countries including Australia, Canada, New Zealand, Palestine, Sweden and Russia, while parallel meetings of commemoration were held in Lisbon by Portugese agriculturists and in Cincinnati by American scientists.

Presiding at the luncheon Lord Radnor said Rothamsted's first century had been

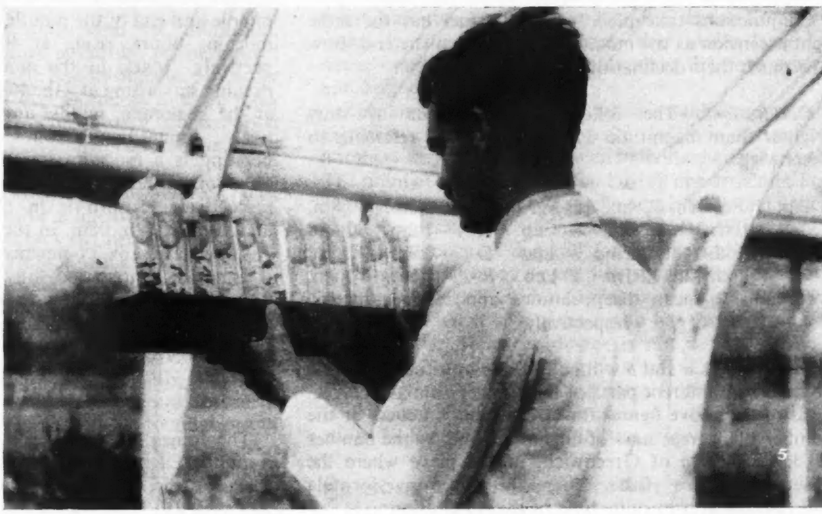
FIGS. **1.**—*This research worker is investigating the influence of composts, etc. on soil fertility.* **2.**—*Counting nitrogen-gathering bacteria from soil.* **3.**—*Spectrograph for analysis of plants and soil.* **4.**—*Barley plants growing with their roots kept cooler than their*

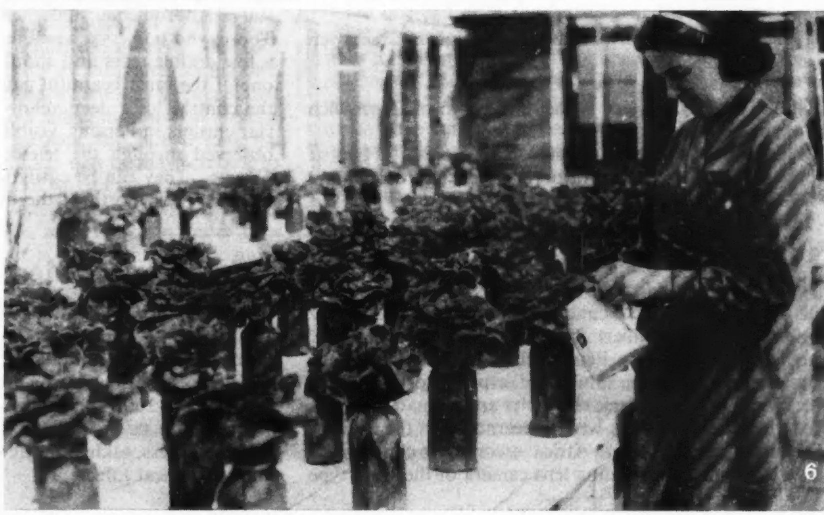
WORK ROTHAMSTED

STILL GOES ON

very valuable to agriculture and he had great hopes that the second century would be even more profitable. Referring to the retiring director, he said that Rothamsted and agriculture owed Sir John Russell a great debt of gratitude. Mr. R. S. Hudson spoke of the origins of Rothamsted and the work of Lawes and Gilbert on artificial fertilisers, which he decribed as having done more for world agriculture than any other piece of research before or since. But for the development of "artificials" we might have been beaten by starvation in this war.

shoots. **5.**—*The clover plants in the left-hand tube have a beneficial kind of bacteria growing in their roots and are healthy. Those in the right-hand tubes have a harmful kind and are stunted or dead.* **6.**—*Finding out what kinds of food 'lettuce need to make good hearts.*





The Night Sky in September

M. DAVIDSON D.Sc., F.R.A.S.

The Moon.—Full moon occurs on September 14d. 03h. 40m., U.T., and new moon on September 29d. 11h. 29m. The following conjunctions will take place:

Sept.			
2d. 00h.	Mercury in conjunction with the moon	Mercury	7° S.
20d. 03h.	Mars „ „	Mars	4 N.
21d. 05h.	Saturn „ „	Saturn	3 N.
25d. 14h.	Jupiter „ „	Jupiter	0·3N.
26d. 16h.	Venus „ „	Venus	8 S.

Conjunctions take place when a planet has the same right ascension as the moon. The figures at the end show how much their declinations differ.

Occultations.—The following occultations of stars brighter than magnitude 6 occur, the times referring to Greenwich:

				a	*b*
Sept.	8d. 21h. 02·4m.	15 Sgr	D	−1·2m.	−0·8m.
	10d. 21h. 27·3m.	σ Cap	D	−1·2m.	+0·4m.
	26d. 11h. 08·2m.	α Leo	D	−0·9m.	−2·5m.
	26d. 12h. 12·1m.	α Leo	R	−1·5m.	−0·9m.

(D and R mean disappearance and reappearance, respectively).

The symbols *a* and *b* will be inserted in future to enable observers in different parts of the country to make corrections to the above figures for Greenwich. Let $\Delta\lambda$ be the number of degrees *west* of Greenwich and $\Delta\varphi$ the number of degrees *north* of Greenwich, of the place where the observations are made. Then the following formula will give the approximate time of the occultation:

Time of Occultation = Predicted Time for Greenwich $+ a{\cdot}\Delta\lambda + b{\cdot}\Delta\varphi$.

Notice that if the place is east and south of Greenwich the sign of *a* and *b* will be —. Example:

What will be the time of the occultation of α Leo at Stonyhurst College Observatory, given that Stonyhurst is 2°·47 west and 2°·37 north of Greenwich?

Predicted Time for Greenwich	26d. 11h. 08·2m.
$a{\cdot}\Delta\lambda$	-2·2m.
$b{\cdot}\Delta\varphi$	-5·9m.
Time at Stonyhurst	26d. 11h. 00·1m.

U.T. (Universal Time) or the same thing, G.M.T. (Greenwich Mean Time) is always used, *not local time*.

The Planets.—Mercury is an evening star at the beginning of the month but is approaching the sun and is in inferior conjunction on September 24. On the first of the month it sets at 19h. 14m.—only quarter of an hour after sunset, and its longitude is then 26° east of the sun. Venus is in inferior conjunction with the sun on September 6. At the middle and end of the month the planet can be seen in the morning hours, rising at 4h. 43m. and 3h. 20m. respectively. Mars, in the constellation of Taurus, is an evening star, rising at 21h. 46m., 21h. 12m., and 20h. 30m. at the beginning, middle and end of the month, respectively. Jupiter moves from Cancer to Leo during September and is a morning star, rising at 3h., 2h. 15m. and 1h. 33m. at the beginning, middle and end of the month, respectively. Saturn is in the constellation of Taurus and rises at 22h. 08m. in the middle of September. The Autumn Equinox commences on September 23d. 22h.

Times of sunrise and sunset are given below, the latitude of Greenwich being assumed:

	Sunrise	Sunset
September 1	5h. 11m.	18h. 49m.
15	5h. 32m.	18h. 18m.
30	5h. 57m.	17h. 42m.

The longer evenings provide opportunities for seeing a number of interesting sights in the heavens, such as the Pleiades, the variable star Algol, the Great Nebula of Andromeda, just visible to the naked eye close to the star ν Andromedæ, and many other objects of interest. Those who possess a small telescope will enjoy looking at a few double stars and should not miss γ Andromedæ—one of the most beautiful pairs in the heavens, presenting the contrast of a deep yellow and a sea-green. Two fine star clusters in Perseus, visible to the naked eye, should be observed through the telescope as they are magnificent objects. They can be easily found in the "sword-hand of Perseus", just north of the fifth magnitude star h Persei.

South African Soldier Wins Science Medal

THE Charles Chree medal and prize have been awarded to Professor (now Brigadier) Basil F. J. Schonland, F.R.S., who is Director of the Bernard Price Institute of Geophysics, Johannesburg. This soldier-professor has done much work in atmospheric electricity and cognate subjects. Firstly, his investigations were concerned with the polarity of thunder-storms in South Africa; secondly he experimented with the use of a rotating lens camera of the Boys type in connection with lightning; and thirdly he worked upon the nature of atmospherics and the part played by the ionosphere in determining their structure.

The presentation was made at a meeting of the Physical Society on 16th July, when Brigadier Schonland, who happened to be in England, delivered the second Charles Chree address, taking as his subject "Thunderstorms and their Electrical Effects".

Economic Planning

L. DELGADO, Ph.D.

ECONOMIC Planning is much under discussion these days. And rightly so, for it is a subject of the first importance to us all. Some countries, such as Germany, have used economic planning to prepare the more efficiently for total war; others, such as Russia, in the first place have had social welfare mainly in mind; while others again, like the U.S.A., have introduced their Tennessee Valley and other schemes alongside unmitigated private enterprise. And we in England, with our recent plethora of Royal Commission reports, have much economic planning immediately before us. So it is clearly important that we should consider more precisely what we mean by economic planning.

Relative Scarcity of Resources

By planning, economists understand the utilisation, under the guidance of a central authority, of the limited resources of production to their best advantage. In order to appreciate to the full the implication of this, we must realise that at present our economic system is based upon scarcity and that its main-spring is the profit motive. The scarcer a thing is relative to demand the higher will be its price: the value in use plays only a secondary role. Thus, a single pair of silk stockings or a lip-stick may well cost more than a substantial meal or some necessary article of clothing. And silk stockings and lip-sticks will be made at the expense of other things while it is profitable to produce them. Chinamen, and even Englishmen, may starve materially, mentally, or industrially for lack of resources, which, it is important to bear in mind, are strictly limited.

Why is it that "planning" has only recently come into prominence? Has not an unplanned economy served us well in the past? England established the foundations of its greatness during the industrial revolution, the golden age of "laissez-faire" and of the individualism so highly praised by Adam Smith. Until the end of the nineteenth century, the world was passing through an individualistic stage. Adam Smith said in his famous book, *The Wealth of Nations*, that individual self-interest was at the root of progress because the study by an individual of his own advantage naturally and necessarily led him to prefer that employment which was most advantageous to society. This assumes a harmony between the public and the private interest. This assumption may or may not be true —many authorities deny it—but we can see that in a world where resources are scarce occasions may arise, as at the present time, when one type of production must take precedence over another, that is, that guns may be more desirable than butter in time of war. Nevertheless, in the nineteeenth century individualism was in the air; even British Trade Unionism accepted the capitalist system that embodied this philosophy and made its peace with it.

Pricing System

Undue virtue was attributed to the familiar pricing system, which automatically adjusts production to demand. It does not follow, of course, that what is demanded by a section of the community is what is most necessary to society as a whole. In the nineteenth century it was believed by all but a very few that the balancing of demand by production as achieved through prices excluded the possibility of the wrong things being brought into being. Surely, it was argued, any errors would be automatically corrected. Any article that was priced too high would not sell: there was always a price at which demand would clear the market, and if this price were not sufficiently remunerative to the producer he would go out of production. Most resources were kept fully employed and few were idle. And this was true at that time. Industrial workers living in insanitary and incredibly dull surroundings, working long hours, demanded gin to brighten their lives; and the distillers saw that the demand was met, using, in the process, resources that would have been better employed in providing sounder drainage schemes and brighter homes.

This kind of problem arises because wealth and marginal significances (i.e. the preference for one article over another) vary so widely between individual and individual. The point at which we will stop buying one article and take another depends upon our stocks of this and other articles, upon its price, and upon our income. What may be extreme urgency of demand for one person may, at the same price, represent a very low significance for another person. A meal is a very different proposition to a starving man from what it is to a man who has just eaten his fill. To the latter a further dinner is not at all urgent: he would rather spend a shilling on a seat at the theatre. To guard against the dangers arising from these differing preferences, we resort to the plan of rationing and price control whenever it is essential to avoid waste.

Reasons for Progress of 19th Century

No one can deny that great progress was made during nearly the whole of the nineteenth century. Our resources were fully employed in this country. A rapidly increasing population found plenty of work, and found it at a very tender age. The principle of joint stock limited liability made huge sums of money available to industry, while a spate of banks created much credit which found eager users.

But the fact that the productive capacity of the country was extensively employed did not mean that planning was not necessary. Starving Chinamen demanded food, as millions of Englishmen demanded better housing, but these demands were unheard because they were ineffective, and they were ineffective because the demand was not backed by adequate purchasing power. It is to avoid this error that the United Nations are making currency plans. It matters little whether the basis of currency be called "unitas", "bancor", or "utopes"; the important thing is that it shall release purchasing power when and where best required, and this is one aspect of planning.

During the whole of the industrial revolution until the end of the nineteenth century population was expanding and, because of this, demand was roughly predictable. With expanding population went expansion of industrial equipment.

Unpredictable Demand of Modern Times

Already at the beginning of this century it had become evident that the population was becoming stationary, and this tendency was confirmed after the war of 1914-1918. This fact was true not only of England but of every other advanced industrial country. From this it followed that in most of the rich areas of the world less money was being spent in rearing families and that enormous sums became available for luxuries and semi-luxuries. This has meant the rise of important light industries, such as radio and refrigerator manufactures. This was reinforced by the fact that a larger proportion of the population was gainfully employed. Hence we had sea cruises and motoring which became the quasi-necessities of the million instead of being the pleasures of the few.

Now, it is very difficult to predict in which direction this type of expenditure will go. It is greatly affected by unmeasurable psychological factors. A wet summer drove millions to the cinema; fine week-ends sent petrol consumption soaring. This instability of demand was reinforced by a change in the distribution of income that had been going on since the beginning of the century. Wages throughout the world, and particularly in England and the United States, had been rising. This was largely due, in England at least, to an increase in the bargaining power of labour, and generally to the increased productivity of labour, which enabled workers to claim a larger proportion of the proceeds of their efforts.

This same productivity of labour also resulted in a reduction in the hours of work and a corresponding increase in the time devoted to leisure, and this also tended in the direction of instability. It was becoming more than ever difficult to predict demand. A change of fashion might leave a large batch of resources—including human resources—without employment. The transfer of resources from one employment to another is always attended by some sacrifice. In Victorian times it was possible for unemployed labour to go overseas. Englishmen went to Canada and the U.S.A.; Italians went to South America. Since the last war this has not been possible because of immigration restrictions. Moreover, industry has become very specialised and its organisation very complex. Minimum wages imposed by law or through the improved bargaining power of labour together with unemployment benefit given by the State have resulted in a great rigidity of the industrial system. In Victorian times, unemployed labour that did not emigrate was absorbed in another trade, perhaps at very low wages. (In fact, the gold standard in its pure form requires that wages should be capable of being reduced.) Now, however, the lowest wage must be a fair amount above unemployment pay.

The changes in the character of demand due to these causes has, we repeat, rendered the anticipation of consumers' demand more and more difficult, and this problem has been accentuated by the great progress made in recent years in the technique of production. Production is now very elaborate and roundabout (i.e. consists in various specialised processes) making it essential to make forecasts of demand further and further ahead. It follows, therefore, that lack of success in one branch of production has repercussions in ever-widening circles upon industries only indirectly related to the manufacture in question.

Foresight is not enough

The insistence of the economists on the need for planning does not leave out of account the method and order by which our present system has been built up. In the most primitive economy some foresight is necessary. For instance, Robinson Crusoe utilised part of his resources to clothe and shelter himself, part for defence, and some for cultivation and hunting, in such proportions as he thought most advantageous for each purpose and taking into consideration the limits imposed upon him by circumstances. Modern industry does no more than this.

How to make the best use of resources has always been the object of the most serious study by every undertaking engaged in production. The factors that have complicated industry in the last half-century—notably the drift from the heavy to the light industries—have made such planning more vital than ever. In recent years business forecasting has become a highly skilled profession. Statistics and research are everywhere the handmaids of production and distribution. We have had vertical combinations in the large-scale heavy industries, whereby all the productive processes are under one management. Thus, the United States Steel Corporation own their own coal and iron ore mines, make their own iron and steel, and manufacture on a very large scale a great variety of products, e.g. locomotives, rails, rolling stock, steel plates of all kinds, machinery of every description, etc. The same is true of many other similar firms, such as Vickers, Krupps and so on.

We have also horizontal combinations, in which firms making the same kind of product amalgamate: thus, coal mining companies, textile undertakings, or motor car manufacturers will join forces. There exist also many Trusts, Cartels, and monopolies; there are agreements, tacit or otherwise, to control output or to limit selling areas.

All this organisation presupposes planning, though not the kind of planning envisaged by economists. The arrangements made by industries in this connection are made frankly in their own particular interest. They may, through the benefits of large scale production, result in lower costs of production and so favour the consumer, but this is incidental and not at all the object of the scheme. Many such schemes are restrictive, and far from making full use of productive resources they waste the factors of production. Examples that come to mind immediately are the burning of "surplus" cotton in the U.S.A., of coffee in Brazil, allowing oranges to rot in Spain or throwing whole cargoes into the sea off Liverpool in order to maintain prices on the English market. The reason advanced is that there has been overproduction, whereas the true cause has always been underconsumption—a disease requiring a very different remedy. Surplus has meant not something which is superfluous but something which cannot be sold at a remunerative price.

Large-Scale Planning

The planning that the Prime Minister has in mind goes far beyond the petty spheres of individual industries. It is not only a question of gearing whole blocks of industry to one another within one country but of rationalising them internationally and in as large areas as possible. Though it may appear somewhat visionary, there is no reason why economically the world should not be considered as a single unit. The fact that such organisation is difficult is no reason why it should not be attempted.

The need for planning on a grand scale after the war will be paramount. Let us look at a few of the problems that will confront us. There is no doubt that the labour force of the world has already been reduced on the battlefields of the five continents and it is to be feared that it will be further reduced before hostilities cease. Enormous damage has been caused to industrial equipment and other fixed capital in nearly every country in Europe by aerial bombardment, and this damage may yet increase. Apart from this, the equipment that remains is being used up at an alarming rate, far quicker than it can be replaced. Industries are being created for specific purposes—to further the war. Some of these industries may be converted after the war to peace production, but not by any means all of them. It is more than probable that the most efficient tank factory in production will be able to supply all the tractors that we are likely to need in England after the war. What are we going to do with the other tank factories? . . . and with the other vast undertakings now on war work? Again, we shall have to strike a balance between our industry and our agriculture. It may be more advantageous, as it has been in the past, to use our resources of labour, land, and capital to make industrial products and with the proceeds buy our foodstuffs in cheaper markets. After all, cheap food makes for low costs of production, but how are we going to reconcile this with ministerial promises to English agriculture?

It seems inevitable that the transfer from war to peace in industry will, without great care, be attended by considerable unemployment even though the working population of the world will be reduced. Any restrictive industrial policy *must* be attended by unemployment. There is, moreover, the problem of wages. Under the rigid system of to-day we have no choice but to accept high wages for some and unemployment for others in times of depression. Unemployment was abolished in Germany and Italy before the war and here during the war. Having seen what can be done, labour is not likely to accept any policy which condemns it to mass unemployment. In any case, a system so wasteful of human resources is not worthy to be maintained. *The Times* of the 9th April, 1943, said: ". . . it is a matter of history that in the past 20 years private enterprise has failed by itself to provide full employment or to secure a distribution of its product which modern civilisation can recognise as equitable. It did not and could not do so because it was not in its nature equipped for these tasks. Now that they have become of paramount importance, private enterprise must be reinforced by other agencies."

The difficulties that may be termed national are indeed formidable. In the international field further complications arise. All over the world war factories are being set up. Will Australia, Canada, or India consent to close down their industries in order to provide us with a market? Almost certainly we in England shall have a competitive advantage in many lines of production, and under free trade we could undersell in most markets. Is this to be the test? Will any country be content to remain purely agricultural? It is to be feared that the answer will be in the negative, especially if in the past it has created industries with the help of tariffs, however uneconomic they might really be. The abolition of barriers to trade will require very careful planning! Statesmen of the world seem to be agreed on the need for such plans. The difficulties will arise in dealing with the mechanism of the new order.

State Control versus Private Enterprise

The world is not at all obliged to accept a system under the immediate control of the State aimed at the supercession of the price economy. The present system may be reorganised in such a manner that, while accepting the pricing system, the broad outlines of the new economy would be planned by a semi-public central authority within the limits of private enterprise. We are not altogether unused to this type of control: in England we have the Metropolitan Water Board, the Port of London Authority, the B.B.C., the Cotton Spinners' Association, the L.P.T.B., the Central Electricity Board, and even the Bank of England, in all of which undertakings profit making is not the main consideration. This method has the great advantage that it evolves naturally from our present system and is completely in accord with English methods; it would not have the repercussions that any more revolutionary change would bring. The State, however, must play an important part on the consumers' side, at least in the years immediately following the war. For some time demand must outstrip supply in many lines of production. Where necessary the State must enforce rationing and fix maximum prices. The State, too, better than any other body, can guide savings into the appropriate channels for investment—a very important aspect of planning.

It seems proved therefore that the planning both of production and of consumption will be vitally necessary after the war. It is fair to point out that an important school of thought, led by Professor Robbins, traces practically the whole of our post-war troubles to State interference in economic matters. This school of thought believes that encouraging monopolistic control of markets, the setting up of pools and restrictive schemes, granting bounties and promoting marketing schemes, the State regulation of wages, and so on, have created a too rigid economic structure which cannot be adapted to changing conditions. Even if all this is true, the explanation may be that the regulation has not been scientific enough. In any case, the adaptability of the economic system requires, among other things, that wages should be reduced in times of depression. Is it not better to plan in order to avoid depressions?

We have dealt with a very big subject in a very few words. There are many problems of great importance which we have lightly passed over. The whole question is one which must have the informed and sympathetic consideration of all and the serious attention of experts at an early date. After the war it will almost certainly be too late.

The Bookshelf

Science in Soviet Russia. Edited by Joseph Needham and Jane Sykes Davies (Watts and Co. 7¼ x 4¾″, pp. 65. 1/3).

"THE task that was undertaken", says Bernal in his introduction, "was not to push forward the bounds of knowledge by the work of a few isolated specialists, but to make scientific the whole productive and cultural activity of 160 million people, only a tiny minority of whom had any previous acquaintance with science or technology." To-day, under the present supreme emergency, we are becoming accustomed in this country to the planning of science: a phenomenon which, on its first development in the Soviet Union, aroused violent opposition in the rest of the world. We are learning that, as Bernal says, "the very consideration of a science planned in relation to social needs brings to light new problems, which in themselves act as a stimulus to radically new discoveries, by breaking up traditional associations of ideas which are the most effective bar to progress." As this book shows, Soviet scientists have been aware of this effect for some time.

J. Needham writes on Soviet biology, and gives a striking example of the interaction between pure and applied science. He describes the extensive development of the very "academic" subject of developmental physiology in the Soviet Union: (in the Military Medical Academy at Leningrad, we learn, the biochemists specialized in studies of chemical embryology). He then points out that this has led to the important operation, associated with name of Filatov, of the grafting of a dead cornea into the eye of a living person, thus restoring sight.

Further references to work on pure science are given by David Schoenberg, who gives a series of examples of fundamental studies in various departments of physics, including quantum mechanics, chemical kinetics and crystalline structure. This article is of special interest, because it includes a description of the working of the Institute of Physical Problems in Moscow, where Schoenberg was a guest worker for a year under the famous Kapitza. The Institute was specially built for Kapitza's work on low temperatures and magnetism.

Schoenberg makes it evident that the status of the scientific worker in the Soviet Union is exceptionally high. "In the Soviet Union scientific research is regarded as a regular and moreover particularly respected profession." From a different point of view this is again made clear in an exceedingly interesting chapter on industrial research by M. Ruhemann, who has also worked in the U.S.S.R.

It will be seen that science in the U.S.S.R. must be extensively endowed. According to G. W. Tyrrell, who deals with the development of mineral resources, in 1936 the expenditure on geological work alone was the equivalent of £38,000,000; and in 1938 we find that, under a new plan, expenditure in this field is to be doubled. Arthur Walton, writing on Agricultural Science, gives an example of the enormous scientific personnel which has been built up: "On the 243,000 collective farms of the Soviet Union it is the aim to have at least one agronomist, one animal husbandman, and one veterinarian, and this aim is near realization." He adds that there are small, but well-equipped laboratories on 20,000 of these farms. The size of this structure makes possible the collection of vast amounts of quantitative data, which are essential for effective planning. The same point is brought out in Ruscoe Clarke's section on medical science. This section is devoted for the most part to a very informative account of the medical services, and might with advantage have included more on research. The section on mineral resources also devotes too large a part to listing the minerals available in the U.S.S.R.

S.A.B.

The Handling of Chromosomes. By C. D. DARLINGTON, F.R.S., and L. F. La Cour. (Allen & Unwin, 1942; 166 pages + 16 plates; 8*s.* 6*d.* net.)

CHROMOSOMES are tiny thread-like structures which make up the nuclei of living cells. They play an essential part in the transmission of characters from parent to offspring in plants and animals, and are directly responsible for the mechanics of inheritance.

It is C. D. Darlington himself who has made the greatest contributions to the theory of chromosome behaviour and has been largely responsible for developing it into a science. L. F. La Cour has worked on the practical side of handling the chromosomes; his extraordinary manual ability has made him one of the most outstanding workers in this field.

The study of chromosomes has been growing in importance in the field of genetics for the past twenty years, but it is only just becoming of interest to workers in other spheres of biology. An example of this increased interest is provided by the work of Koller at Edinburgh in connection with cancer research; and that of Waddington at Cambridge indicates that chromosome work may soon become of great interest to embryologists. This book therefore comes as a response to the growing demand among biologists for information about chromosome technique. The book will be especially useful to teachers of biology, the more progressive of whom are feeling the need for some account of the practical side of this new and important branch of that science.

The Handling of Chromosomes is the only easily accessible source of information on chromosome technique. Its subject matter has been collected from numerous and scattered publications, the value of many of which is difficult to assess. There is also certain information included which has so far not been available elsewhere.

Probably the most useful part of the book is the appendices. The first appendix makes it possible to refer to the most recent papers, of which there is an extensive bibliography, describing the handling of chromosomes in various types of organism. A reference may be found by looking up "meiosis", "spiral structure" or "heterochromatin" and so on. Or the type of organism may be used as a reference, according to its natural classification. Finally, references to organisms may be found classified by the season in which chromosome work on them may be done. A second appendix gives the chief chemical and physical properties of the common reagents used in this work, the composition of the important fixatives, and the methods of preparing various stains and fluids. Photographic solutions and the preparation of food for the fruit fly Drosophila, much used in chromosome studies, are also described. The third appendix consists in fairly detailed schedules of the most useful methods of chromosome preparation. There is also a catalogue of the instruments which are necessary in the work.

The main part of the work includes chapters on the equipment required in chromosome microscopy, giving detailed instructions; on the photography of chromosomes dealing with every stage from the setting up of the camera to the preparation of the photographs for reproduction; and on the interpretation and writing up of experimental results for publication. Fixing, staining, and mounting techniques are described in four chapters. One of the later chapters deals with the special treatments designed to show up certain of the different types of chromosome structure such as the various spiral formations. A second covers the control of ordinary nuclear division by means of X-ray, drugs and temperature change, and a third treats of the control of fertilisation by artificial pollen germination. There is also a study of the induction of haploidy, *i.e.* half-sets of chromosomes in plants and animals.

For such a small book, *The Handling of Chromosomes* covers a large number of topics. In this respect it may be adversely criticised, since it assumes that the reader has no knowledge of microscopical technique, although it is unlikely that anyone would begin microscopy with work on chromosomes. Thus it may be said that a good deal of space is wasted. However, the fact that many biologists lack an expert command of the technique of microscopy goes far to justify this.

The book is concisely written and well illustrated by clear (if not beautiful) diagrams and a magnificent series of chromosome photographs. A general criticism is that there is a tendency to over-simplify and make chromosome technique appear easier than it really is. But the unique experience of Darlington and La Cour as the leading chromosome workers of the day will ensure the success of this book.

J.A.B.

Supersonics: sounds seen but not heard

E. G. RICHARDSON, B.A., Ph.D., D.Sc.

It is a matter of common observation that the human ear becomes less sensitive to pitch the higher up in the scale that a note lies. The uppermost notes of the pianoforte give a much less distinct impression than those near the middle of its gamut. If the piano maker were to continue the scale beyond the normal limit even the sense that a note is of higher pitch than the one before would gradually disappear, and at a frequency of about 200,000 vibrations per second the sense of hearing would fail altogether. This upper pitch limit is a function of the size and structure of the ear, apparently, for it varies from one individual to another; while in the smaller mammals like the dog and cat it lies considerably higher up the scale. That is why a dog may be more readily called to attention by a high-pitched whisper than by a normal voice; its ear is more sensitive to the components of high pitch in the sound.

One's own limitations in this respect may be tested by a little instrument, designed by the psychologist Galton, which consists in effect of a little organ pipe of the flue type. In this a column of air is set into vibration by a jet of wind which impinges on the round lower edge of the metal column which contains it. Two screws are provided for adjusting the pitch; one moves the nozzle from which the air debouches nearer to the lower edge of the pipe, the other moves a piston within the pipe itself, thus altering its sounding length. Both these distances must be decreased as one mounts the scale of pitch until suddenly the sound apparently ceases though air is still leaving the nozzle. The instrument is graduated in terms of frequency of note emitted. An idea of the size of the instrument can be gauged from the fact that a "stopped" organ pipe to elicit a note of 20,000 cycles/sec. in air requires to be only 4¼ mm. long. The apparatus in fact is of the same size as a micrometer screw-gauge, which it resembles in appearance.

It is well-known that sounds are propagated by a series of periodic compressions and rarefactions of the medium which carries them. Vibrations and waves, which although conveyed in the same manner are, from the rapidity with which these compressions and rarefactions follow each other inaudible, are known as supersonic. In the few years since they have been studied they have proved, as we shall endeavour to show, of importance both in the realms of pure and of applied science.

Modes of Production

The first method of producing supersonics in air or in a gas is based on the Galton whistle itself—and differs from it mainly in the greater velocity of jet employed, whereby the energy of the output is much increased. In the common form which this jet generator takes, it is known as the Hartmann oscillator (Fig. 1). If the velocity of the jet is increased above that of sound in air, a series of shock waves originate at the edges of the nozzle and are reflected to and fro on the confines of the jet, giving a criss-cross appearance. The compression of the air along these wave-fronts is so intense that they can cast shadows on a photographic plate in the same way that the fronts of the shock-waves from bullets can be photographed. Fig. 2 shows the appearance of such a jet. The places where the shock waves are reflected at the barrier between the fast-moving air and the static air outside are evidently zones of considerable instability, since if the mouth of the little pipe is placed there its natural tone is excited with considerable vehemence. It is thus only necessary to have a series of little bottle-shaped resonators from 4 mm. in length downwards (or a single one with a movable stopper) to be able to excite the neighbouring air into supersonic vibration at a known frequency. The jet generator has, however, considerable limitations. Apart from the fact that it can only operate in a gas, its frequency is subject to casual variation and is very "mixed" in the sense that many overtones of the fundamental frequency of the pipe are generated at the same time.

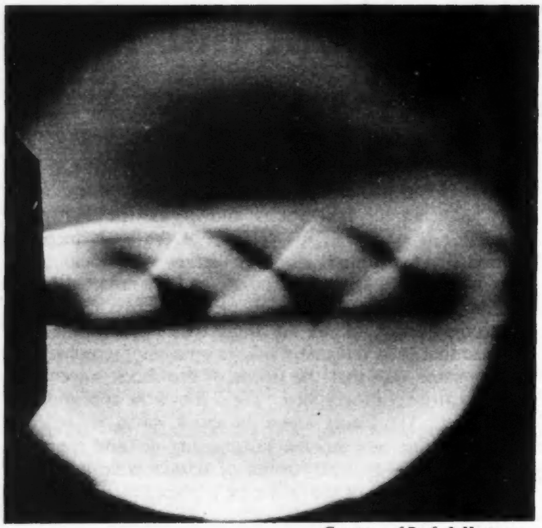
Courtesy of Prof. J. Hartmann

Fig. 1.—Hartmann oscillator for the production of supersonics

The most common type of supersonic generator makes use of the piezo-electric effect. The brothers Jean and Pierre Curie discovered in 1880 that certain crystals when compressed along one of their axes developed charges on two opposite faces, apparent as a difference of potential between the faces. Conversely, if such a difference of potential is applied to an unstressed crystal, strains are set up in the form of a self-compression or extension. It is apparent that if an alternating potential difference is applied to these faces in place of the steady one the crystal will endeavour to elongate and contract rhythmically. Further, if an alternating current is applied at one of the natural frequencies of vibration of the crystal, considered as a disc or rod along the axis in question, resonance steps in and much enhances the mechanical vibration which results.

The piezo-electric resonator, as it is called, was first realised by Langevin during the 1914-18 war, though, since it was given a secret application, his researches were not published until several years later. The means adopted to excite the crystal was to set a thermionic valve circuit into oscillation at a frequency which the crystal, once started in vibration, controlled.

The substances most commonly used as sources in this way are quartz, Rochelle salt, and tourmaline. They are



Courtesy of Prof. J. Hartmann

FIG. 2—Photograph of a supersonic jet

cut into discs or slabs in such directions that electrodes may be applied to carry potential in the direction of one of their crystalline axes. In the case of the slabs, the electrodes are cemented to the top and bottom and the extensions and contractions take place along the greatest dimension. The discs are usually cut so that the motion takes place in the same direction as the applied alternating potential, namely, perpendicular to the flat faces in concertina fashion.

Yet a third source employs the magneto-striction effect which is a similar one to the piezo-electric effect with the potential difference replaced by a magnetic field. The rod is of magnetic material usually an alloy of nickel, and the alternating current to magnetise it at its own natural frequency is supplied by a coil of wire connected into a valve oscillator. When the rod is laid in the coil it alternates in length with the same frequency, sending out longitudinal waves from each end.

The length of quartz slab or of nickel rod to produce a given frequency is determined by the reciprocal of its length and the velocity of sound in the solid. Thus to get supersonic waves of frequency 50,000 cycles/sec. a quartz slab 5·5 cm. is required; for 100,000 cycles/sec. one of 2·75 cm. length—and similarly, for rods in magneto-striction. Typical oscillators of both types are shown in Fig. 3. (The larger nickel rod is 3 inches long.)

Before passing on to consider some of the applications of these radiations we ought to point out that the small size of these sources is a serious disadvantage. If a source of sound (sonic or supersonic) is to irradiate a considerable region—a requirement in many of these applications—it must have a considerable area; for example, a loud-speaker has to have a much larger surface of vibrating area than a telephone head-piece. To get over this difficulty Langevin constructed a sort of sandwich consisting of a large number of little slabs side by side and all having their axes of vibration parallel between two metal slabs to act as electrodes. By the concourse of crystals vibrating together the lower plate was made to move relative to the top one in concertina fashion, and thus a large radiating area was added to the source, when working into water.

In the case of the magneto-striction oscillators, a number of rings threaded together have coils wrapped round them so that they all expand and contract round their circumferences in unison. The energy is received on the surface of a shallow metal horn, so that the radial oscillations are turned through a right angle and sent out from the horn in the form of a beam. Fig. 4 shows the type of oscillator developed by Admiralty scientists and marketed by Messrs. H. Hughes. It is used for echo-sounding in the sea, as described below.

Locating Shipwrecks

In the original application of supersonics, for which the Langevin and Hughes systems were designed, a beam of supersonics was directed through the sea to some hidden object, possibly the hull of another ship or the sea-bed. If the beam strikes the surface at right angles the reflected beam retraces its path. Thus, all that is necessary to detect the existence of the reflecting surface and its distance from the emitter is to send out a short train of waves (covering about one-tenth of a second) and wait until it reappears at the source. By means of a switch which operates automatically when the oscillator has completed the emission of the train, the sandwich and its associated amplifier becomes a detector, the returning wave train setting the quartz into oscillation again for a short time at its natural frequency. The system is then analogous to that by which a boy might send a train of surface waves across a pond by alternately lifting and pushing down a piece of wood floating on the water. If he desists after sending out a short series of waves and these are then reflected from the far side of the pond, the plank will be again oscillated for a short time by the returning waves. The performance of such an experiment will serve to illustrate one factor which is not common to the supersonic gear and its analogue, namely, the slow rate of damping of the surface waves. The board does not come to rest as soon as the boy leaves go, but continues to rock with diminishing amplitude for some time. In comparison, the quartz oscillator is dead-beat. If it were not so, the returning waves might reach it before the original motion producing the emission train had subsided.

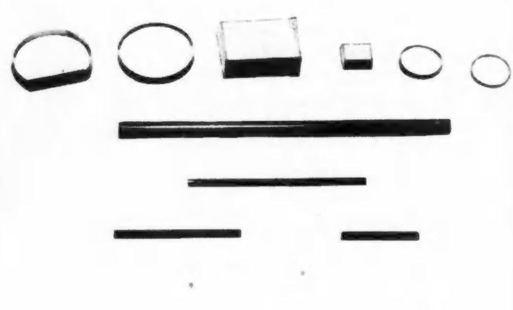


FIG. 3—Piezo-electric and magnetic-stricture sources

In the most fruitful application of this reflection method it is the distance below the ship of the bed of the sea which is in question, and the process is known as echo-sounding. The action of initiating the supersonic wave train is made to start a pointer moving at constant speed over a dial and the arrival of the first of the returning waves stops it. Since the speed of sound in the sea is known, this clock can be graduated in fathoms or metres (allowing for the fact that the beam traverses the distance to the bottom twice).

Distance is not the only information given by the echo-sounder; something about the nature of the bed may be deduced from an examination of the record of the echo. If the latter is sharp and distinct a correspondingly distinct and hard bed is indicated. If, however, the record is fuzzy with the appearance of some of the radiation having penetrated before being reflected (like what one would expect in a light beam reflected from a mirror from which the silvering was beginning to peel), the inference is that the bed is oozy and indistinct. Indeed, interesting information about the nature of the bed of a lake has been gained by traversing lines across it in a vessel equipped with an echo-sounding device. Wrecks may also be detected (see Fig. 5).

Cracks in Metals

On a smaller scale, a similar idea may be applied to establish the existence of suspected discontinuities in a metal structure in the form of hidden cracks. Since it is not feasible to switch over the oscillator from emission to detection during the passage of the supersonic wave train, a separate emitter and detector are clamped to one side of the specimen at a small angle to each other or, alternatively, on opposite sides of the specimen. When the radiation arrives at a boundary of any kind in the metal, most of it is reflected, so that the existence of a crack in the specimen in line of the beam is shown by a rise in the energy received by the neighbouring supersonic detector or a fall in that received on the opposite side.

Another class of supersonic applications makes use of the concentrated energy to separate out or combine two phases of matter in an intimate mixture. Thus, if air is dissolved in a liquid, it may be driven off if a quartz generator is set in oscillation within the liquid. Even if there is no dissolved

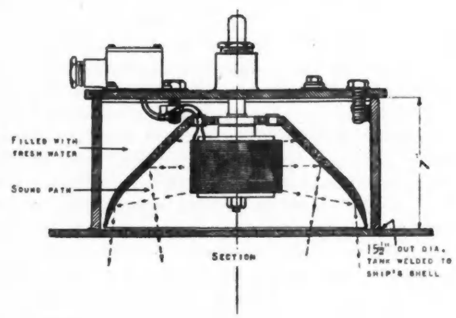
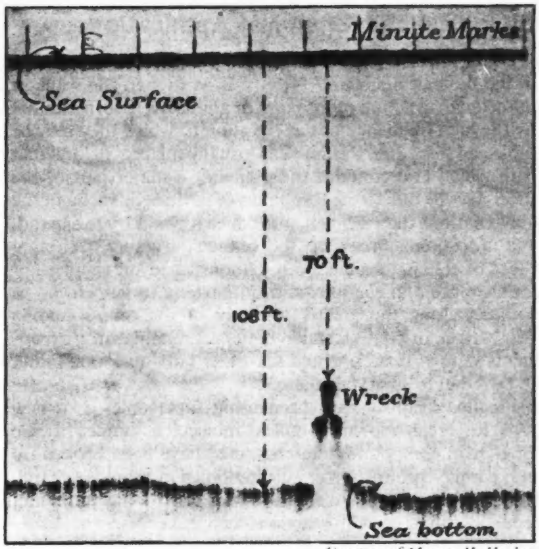


FIG. 4—Echo-sounding gear



Courtesy of Messrs. H. Hughes

FIG. 5—Echo-sounding record

gas, the hydrostatic pressure set up is sufficient to cause cavitation, while if the oscillator is a little below the surface of the liquid and directs a beam upwards the liquid may be forced up in the form of a continuous fountain or mound on the surface. This application has become of some technical importance lately in that metallurgists have been trying to remove the traces of gas, which sometimes become occluded when metals are melted down together to form alloys in the form of fine bubbles, which weaken the structure when they separate out from the alloy as imprisoned bubbles on cooling. Of course the quartz or nickel generator cannot be directly exposed to the melt, but it exerts its effect through a thin metal diaphragm.

If on the other hand the oscillator operates in one liquid over which a layer of less dense liquid is poured (for example water over aniline), the latter is emulsified by the fountain effect, as a cloud of small drops into the former. In this respect, of course, the supersonics are acting in the converse direction, forming a dispersion of one phase into another instead of breaking it up.

A somewhat similar function is filled by supersonics when used to coagulate a smoke or mist or other suspension of a fine powder in the air. Here it is doubtless a stirring-up effect which drives the smaller more mobile ones into collision with the more lumbering large particles so causing them, unless they carry like electrical charges into coalescence, ultimately to form units heavy enough to settle under gravity.

In all these applications the difficulty is to build a system which will irradiate with supersonics a sufficiently large volume. It is of no use, for instance, as one chemical manufacturer did, setting up a high-pitched Hartmann whistle at the bottom of a smoke stack and expecting the fumes to fall incontinently to the bottom! Such an effect would be very localised. For the same reason, the degassing of melts has up to the present scarcely got beyond the model stage.

Biological and Chemical Applications

Other disruptive actions of the radiation may be instanced in the biological sphere. Here, it is as though the walls of the cellular structure of the plant or animal were torn asunder by the high frequency of the vibration to which they may be subjected. As the specimen is usually placed in a liquid bath which also contains the oscillator a major part of the effect may be due to the formation of cavities or vacua in the liquid bathing the specimen, into which its walls try to expand, and in so doing break up the cellular structure. A lethal effect of this nature has been demonstrated on small plant forms, algae and the like, and on bacteria in suspension in liquids. Using the greater intensity of the echo-sounding gear, larger organisms suffer the effect. Langevin's experiments were at first done in a sea-water tank and were found to be lethal to small fish therein.

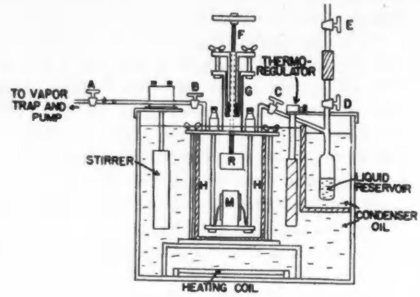
Finally, chemists have been using supersonics as a new tool to break down complex molecules. Some of the long-chain compounds, starches, etc., have been broken up into simpler groups under this action. On the other hand, chemists have attributed a catalytic action to the radiation, reporting that certain reactions can take place at lower temperatures in its presence.

In assessing all these applications, and especially in connection with the last one, it is necessary to beware of two conflicting issues. Apart from the supersonic actions we have already recorded, there is one considerable result of the dissipation of supersonic energy (more noticeable in liquids than in gases), i.e., the production of heat. As an "application" demands more concentrated supersonic energy, so the investigation produces more heat. If this is not quickly conducted away from the apparatus, one cannot tell how much of the recorded "effect" is simply due to rise of temperature. In fact, when a supersonic oscillator is working all out in a liquid, a glass rod held at one end whilst the other projects into the liquid (without touching the source) soon becomes too hot to hold! The early workers in the subject often did not control the temperature sufficiently for their reported results to be free from this complication.

Propagation in Gases

The first evidence to show that the characteristics of supersonics were different from those of low-frequency sounds came when their propagation through gases were examined. Until then it was believed that the velocity of sound was the same for all frequencies. Certainly we know that this is so for audible sounds. The best proof of this is that the music of a band in the open air is not distorted at a distance by the overlapping which would result if the high-pitched tones travelled at a different velocity to the low-pitched tones. (It is thought-provoking to reflect that if this had been so, the system of harmony and counterpoint as we know it to-day would probably never have been evolved.)

The story begins with an observation by the American physicist, G. W. Pierce, in 1925, that the velocity of sound of frequency in the neighbourhood of 100,000 cycles per second exceeded that at sonic frequencies in carbon-dioxide, and further that such radiations were strongly absorbed. Since then the effect has been confirmed for nitrous oxide and sulphur dioxide at frequencies higher still. Up to the upper



Courtesy of Messrs. H Hughes

FIG 6—Apparatus for measuring supersonic wavelengths

limit of frequency to which such measurements are at present possible (abont 2,000,000 cycles per second) oxygen, nitrogen and the rare gases have proved immune to the effect. The vapours of carbon disulphide and benzene also exhibit the same anomaly.

A number of methods have been developed for investigating this "supersonic dispersion" as it is called, but we shall describe the original method of Pierce, as it is the simplest and—at any rate where a knowledge of the velocity of the radiation is required—quite as accurate as the more complicated systems which have been developed since. Fig. 6 shows the form of it, as adapted by W. Railston for investigating the influence of temperature and pressure on this anomaly. A quartz crystal M in the shape of a slab is mounted within a cylindrical chamber, to which the gas can be admitted, in such a position that when connected into the appropriate driving circuit it radiates a beam of supersonics along the axis of the chamber. Facing the crystal so that the beam impinges on it perpendicularly is a reflector R in the form of a glass plate which, by means of a micrometer head F outside the chamber, can be moved gently to and fro along the axis. When the crystal radiates, a system of waves and their reflections are bandied to-and-fro between the sender and reflector. If the distance between them is adjusted to an exact multiple of the half wave-length for the radiation in the gas, the column of gas will be in resonance at the frequency in question and the resulting stationary wave system will react on the sender causing a change in the load on the circuit which is driving it. (The reader familiar with the Kundt's tube experiment of elementary practical physics will recognise that we have here, in effect, the same set-up. The crystal takes the place of the glass or wooden rod; the driving circuit takes the place of the piece of discarded "gentlemen's suitings" and the hand that wields it to set the rod in vibration; the reflector takes the place of the adjustable piston.) Lycopodium powder may also be used to indicate when resonance has been attained in the supersonic apparatus, but it is more convenient to see when the oscillator is being loaded by the column by observing—for example—the change in the plate current in its output valve. (This is rather like seeing when a radio receiver is tuned in by an indicator in the circuit of the detector valve).

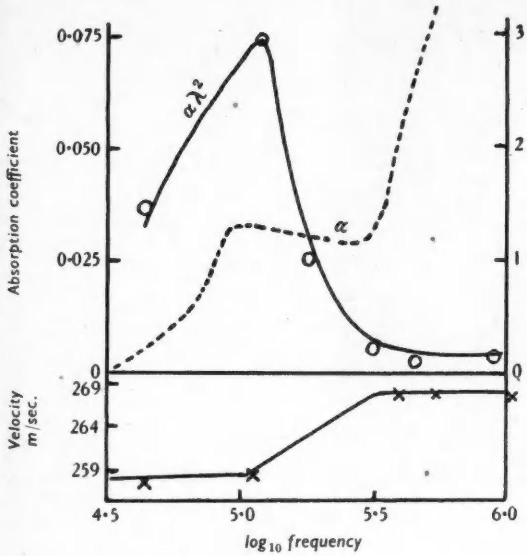


FIG. 7—Graph showing variations with frequency of velocity of sound in carbon dioxide.

When the crystal oscillates in carbon dioxide and the reflector is slowly moved back, the output of the oscillator shows a series of peaks and troughs, as the column of air gets in and out of resonance, and the peaks diminish in height as the reflector is withdrawn. From the movement of the reflector between two successive peaks, we derive the wave-length in the gas and so—knowing the frequency of the emission—its velocity in the gas. From the rate of decline of the peaks we infer the extent of the absorption in the gas. (In carbon dioxide the latter is such that when the reflector is 2 inches away from a source of 100,000 cycles per second, nothing is left of the radiation by the time it has got back to the crystal to affect the driving circuit. In oxygen on the other hand, this reaction is still appreciable at 6 inches).

When experiments in a gas like carbon dioxide are carried out at various frequencies, the general features of the results are as follows (cf. Fig. 7, which shows results in carbon dioxide. The product of the absorption coefficient (α) and the square of the wave-length (λ) is a constant in a normal gas).

The velocity after falling a little rises sharply and thereafter tends to fall a little, though never—within the reach of our possible range of frequency at the moment—recovering its low-frequency level. The absorption in the same region rises steeply with frequency. One other observation, and one which requires more elaborate apparatus than that here described, refers to the way in which the supersonic beam behaves in the gas. Whereas its path at lower frequencies is forthright to and from the reflector, in this dispersion region a considerable amount is scattered to one side, just as a beam of light is scattered by the fine suspension of droplets in a mist. This, in part, accounts for the gradual blotting-out of the peaks as the reflector is moved back.

Relaxation and Dispersion Theories

How is this phenomenon to be explained? There are two theories, neither entirely satisfactory.

The Relaxation Theory supposes that a molecule possesses a sort of stiffness which forces it to take its time in responding to high frequency impulses. The reader is probably familiar with the analogy of the shunting train as a basis for explaining the behaviour of molecules propagating sound-waves by longitudinal vibrations. If we have a line of trucks connected by spring-buffers and let the locomotive give the end truck a blow, this pulse is transmitted along the series at a speed which is greater as the trucks are more tightly coupled. If, in fact, there were no springs in the buffers and the trucks were rigidly coupled, the blow would reach the far end of the train with the speed of sound in steel. Now if with the usual loose couplings the end truck is oscillated to and fro on the rails to simulate a periodic compression and rarefaction this will travel down the series, each truck taking up the impulse and as it relaxes handing it on to the next in line. If, however, the first in line can be oscillated at such a rate that before each truck has relaxed from the initial compression of its springs the next following rarefaction has caught up with it, it must have its movement considerably curtailed, for the rarefaction tends to annul the effect of the proceeding compression which is not yet over. Thus, when the time period of vibration that is being transmitted approaches the time which the truck's springs require in order to relax—their "relaxation time"—the line of trucks begins to act like a rigid system of connected bodies, the springs cease their functions and the vibration is transmitted at a higher speed.

This is what is supposed to happen to the molecules of carbon dioxide. Their time of relaxation may be of the order of one hundred thousandth of a second, so that they are stiffer to frequencies above 100,000 cycles per second than to those below it.

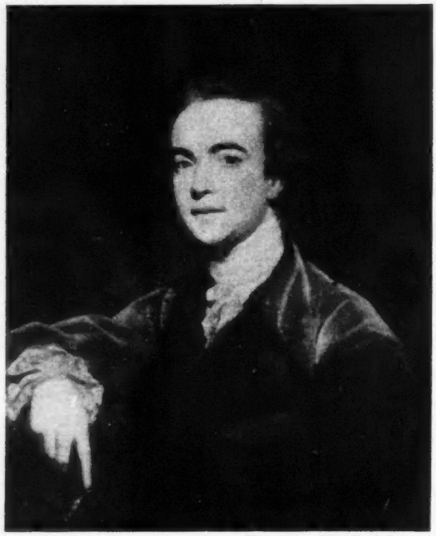
The Dispersion Theory lays emphasis on the scattering aspect of the radiation. It is significant that those gases and vapours which scatter supersonics most markedly are also noted scatterers of light. They are substances which have a tendency to form aggregates, so that the medium is "speckled" and no longer isotropic in the sense that distilled water is—like a pre-war currant bun as compared to a bread-roll! Such media exhibit changes of velocity with frequency and degradation of acoustical energy due to interference.

Both these theories have their limitations, and the experimental data collected to date are insufficient to found a completely satisfactory theory even if one were available ready made. At present, the relaxation theory has more adherents.

A rather similar phenomenon has been observed with mixtures of gases or vapours. As we have remarked, pure oxygen and nitrogen have not shown dispersion, but if a little water-vapour be added they acquire a variation of velocity and absorption with frequency.

The effect of humidity on absorption in air at audible frequencies was first noticed by V. O. Knudsen, when he was estimating the effect of water vapour in the air in a building on its acoustical properties. The phenomenon has since been pursued with oxygen into the supersonic gamut and it has been shown that for every frequency there is a value of the humidity at which the absorption is a maximum

[Continued on p. 257.



Courtesy of the Earl Spencer

FIG. 1.—"The study of science in India commenced with the arrival of Sir William Jones in October, 1784."

Scientific Work in India

SIR LEWIS L. FERMOR, D.Sc., F.R.S.

THAT a high degree of civilization had already been reached by the peoples of the Mediterranean basin and of the Middle and Far East—*e.g.* of Greece, Egypt, India, and China—at a time when our ancestors in Britain still dressed in woad and skins is known, at least vaguely, to all educated people. But it is not generally realized how far back into the dim past these civilizations extended; and most people are unaware that a study of the facts of nature was an integral part of these civilizations, so that natural science originated in this, humanly-speaking, distant past.

The full facts of this early knowledge are, of course, not now forthcoming. But it is known that scientific investigations were made as early as the 4th or 3rd millenium B.C. in the form of astronomical observations by the Babylonians, and that the Egyptians had developed certain branches of mathematics, also by the third millenium B.C. The real birth of Science may, however, be assigned to the period of pre-eminence of the Grecian schools of Asia Minor, Greece, and Alexandria, between 600 and 200 B.C., when such intellectual giants as Pythagoras, Hippocrates, Socrates, Plato, Aristotle, Theophrastus, Euclid, and Archimedes flourished. Greece was at its Golden Age in 450-400 B.C. at Athens, and it is then, according to some, that Science really was born—Greek science including mathematics, astronomy, biology, medicine, physics and chemistry. The Roman Empire followed Greece; but with the break up of this Empire a thousand years of darkness descended upon the world, until the Renaissance, the intellectual awakening during the 14th, 15th, and 16th centuries in Modern Europe. The Renaissance was preceded and rendered possible by the foundation of universities in Europe at Paris, Bologna, Salerno, Oxford, and Cambridge, beginning as early as the 11th century A.D. and based usually on old monastic schools. The Renaissance was a period of efflorescence in all branches of learning—letters, art, science, and mathematics. It is not necessary to review here the growth of scientific knowledge during the Renaissance: it is sufficient to mention such outstanding names as Roger Bacon, Leonardo da Vinci, Copernicus, Galileo, Francis Bacon, and Descartes, followed by Isaac Newton in the 17th century, to bring us down to the full tide of modern scientific research, with the foundation of the Royal Society of London in 1660 and of the *Académie royale des sciences* in France in 1666. This flood of modern scientific research has since spread throughout the civilized world, including Asia.

Before leaving the European scene it is desirable to mention the meaning of the word Academy. It will surprise many readers to learn that the *first Academy* was a pleasure garden in Athens which is supposed to have belonged to an ancient Attic hero named Academus. The garden was walled in by Hipparchus, and eventually bequeathed as a public pleasure ground by Cimon to his fellow-citizens of Athens. In this garden the Greek philosopher Plato taught for nearly 50 years; and the Academy thus started lasted from the days of Plato to those of Cicero, that is for over 300 years. We thus see

that the original Academy dated from about 400 B.C. and was a garden used for philosophic teachings and discussions. In this original Academy the old philosophers must have discussed arts and letters, mathematics and science, as well as philosophy strictly so called; so that a true Academy, without qualification, should be on as broad a basis. The Royal Asiatic Society of Bengal, to which reference will be made later, is one of the few institutions that complies with such a definition, being essentially an Academy of arts, letters, philosophy, and sciences.

Ancient Hindu Science

It must not be thought that during the whole of the several millenia between the early astromonical observations of the Babylonians and the introduction of modern science in India by Europeans, Asia has been scientifically asleep. The Hindus and the Arabs have also made their contributions. The Hindus in particular made advances in mathematical science following the stimulus to intercourse with Europe, resulting with the conquests of Alexander the Great. All ancient Hindu science may not date, however, from the introduction of Greek influence. For it has become evident (*e.g.*, from the researches of scholars into ancient manuscripts) that the ancient Hindus had exact knowledge of the habits of fishes and of the modes of their locomotion, knowledge that has been rediscovered only in the last few years by zoologists in America and Europe. It is known also that the ancient Hindus had considerable knowledge of medicine and chemistry[1]. Further researches by oriental scholars into old Sanskrit and Pali texts may bring to light knowledge of other branches of science possessed by the ancient Hindus. Indeed it seems likely that when the full range of the early knowledge of the Hindus in the realms of science and mathematics comes to be known, as far as this is possible, it may prove to be partly indigenous and pre-Greek and partly based on Greek influence.

Ancient Arab Science

The ancient Moslem world has also contributed to scientific research. For although the first results of the Arab irruptions into Asia and North Africa were disastrous, in that the Arabs completed the destruction of the world-famous library of Alexandria—a process already carried out partly by Christians about a century earlier—yet, as so often happens, the conquerors soon settled down and took an interest in the learning of the conquered, collecting and translating Greek manuscripts, and also the works of Hindu writers, so that Arab science was built on Greek and Hindu foundations. The Arabs took a special interest in astronomy, chemistry, and medicine, concerning which there is still much to be learned from the study of ancient Arabic manuscripts, a branch of research on which much has been published of recent years by the Asiatic Society of Bengal. But the special ability of Muslim civilization has lain in arts, crafts, and industries, as exemplified by the superb buildings, and the beautiful porcelains and tiles, manuscripts and pictures, carpets and metal work, of Egypt, Mesopotamia, Persia, and India[2].

[1] Sir P. C. Ray, *History of Hindu Chemistry* (1902).
[2] See *The Legacy of Islam*, Clarendon Press, Oxford (1931).

Development of Modern Science in India

We may now notice briefly the development of science in India since the arrival of western civilization. The history of the modern development and study of science in India really commences with the arrival of Sir William Jones in October, 1783, as a Puisne Judge of the Supreme Court at Fort William in Bengal. Sir William Jones was a genius and the greatest oriental scholar who ever came to India. He quickly noted the lack of any organized association in Calcutta as a drawback to progress, and in 1874 organized and founded the *Asiatick Society*, of which he became the first president, with Warren Hastings as its Patron. The comprehensive phrases in which, in his inaugural address, Sir William Jones described the objects of this Society have since been paraphrased into:

> "The bounds of its investigation will be the geographical limits of Asia, and within these limits its enquiries will be extended to whatever is performed by man, or produced by nature".

From this it is clear that the Society was founded with a scope equivalent to that of an Academy in the ancient Greek sense of the term. The Asiatick Society later became known as the Asiatic Society of Bengal, and on celebrating its 150th birthday in 1934, it was honoured with the appellation Royal. Apart from its ordinary membership this Society has a Fellowship restricted to 50, for both Letters and Science together. The Royal Asiatic Society of Great Britain and Ireland is a later foundation (1823) by a former President of the Asiatic Society retired from India.

The Asiatic Society has been mentioned at length because from its activities have sprung by far the larger part of subsequent scientific (and literary) activity in India, not forgetting in particular philological research into ancient scripts, which render possible the unravelling of the past.

Other societies founded during the 19th century that still exist are the Bombay Natural History Society (1883) and the Agricultural Society of India (1820), now the Agri-Horticultural Society of India.

We may now notice *scientific services* founded during this formative period in Indian science. During the early days of the East India Company there were no scientists employed as such, although the Company retained the services of medical officers, surveyors, and assayers at the mint. In consequence the early scientific work of India was practically all amateur work by medical men, enthusiastic army officers, and officers in civil employ. It was one of these assayers, James Prinsep, who in 1838 deciphered the ancient Brahmi script used in the rock-cut inscriptions or edicts of the Indian Buddist King, Asoka (died *circa* 237 B.C.). This achievement was of the same rank as the decipherment of the hieroglyphics of Egypt, and ushered in the scientific era of Indian archaeology. Prinsep also showed that Brahmi is the ancestor of all the modern Indian scripts of Sanskritic origin.

The first scientific service to be formed in India was the Trigonometrical Survey of the Peninsula in 1800, which on amalgamation with other later surveys became the Survey of India in 1878. The Geological Survey of India, founded in 1851, still continues under this title. The Botanical Survey of India was formed in 1889 and was based on the

Current Science

FIG. 2.—H. J. Bhabha, D.Sc., F.R.S.

Current Science

FIG. 3.—Sir Shanti Swarup Bhatnagar, D.Sch., F.R S.

Current Science

FIG. 4.—Professor K. S. Krishnan, D.Sc., F.R.S.

Exclusive News Agency

FIG. 5.—Sir Chandrasekhara Venkata Raman, D.Sc., F.R.S

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Royal Botanic Gardens at Sibpur, near Calcutta, which was founded in 1788. The first Museum was that of the Asiatic Society, which led to the foundation of the Indian Museum in 1866 and the Zoological Survey of India in 1916. Meterological observatories date from 1792 in Madras, 1824 in Calcutta, and 1826 in Bombay, leading up to the foundation of the Meteorological Department of the Government of India in 1875.

These scientific activities were the responsibility of the East India Company up to 1858, when the Crown, after the Indian Mutiny, took over the Government of India, and thereby became financially responsible for the maintenance of these activities. So that the Government of India and the Asiatic Society of Bengal must be regarded as the father and mother respectively of scientific research in India.

Twentieth-century Specialist Organizations

In the present century a new stage in the development of scientific research in India has been reached, namely a period characterized by the formation of numerous *Government research institutes*, and numerous specialist scientific societies.

Taking these two groups in order we may note that official provision for research in the applied sciences, Agricultural, Forests, Medical, and Veterinary research, has come at a much later date than for the surveys, geology, botany, zoology, and meteorology, and belongs in the main to the twentieth century.

In Agriculture provincial Departments of Land Revenue and Agriculture, or of Agriculture alone, were formed towards the end of the nineteenth century, followed by the Indian Agricultural Research Institute at Pusa in 1903 (since re-erected at Delhi after destruction by the great Bihar earthquake of 1934). For Veterinary Work the Imperial Bacteriological Laboratory was opened at Poona in 1890, and is now the Imperial Institute of Veterinary Research at Muktesar. The Forest Research Institute at Dehra Dun was opened in 1906. All-India provision for Medical Research is represented by the Central Research Institute founded at Kasauli in 1906, and the All-India Institute of Public Health and Hygiene founded in Calcutta in 1934. There are also several medical research institutes administered provincially, such as the School of Tropical Medicine, Calcutta, and the Haffkine Institute, Bombay.

Mention must also be made of the Indian Institute of Science founded at Bangalore in 1911, out of munificent grants by the Tata family of Bombay Parsees, supplemented by Government grants. There is also the Indian Association for the Cultivation of Science established by private enterprise in Calcutta in 1876, and now mainly a research association.

In the matter of *specialist scientific societies* the geologists gave an early lead with the foundation of the Mining and Geological Institute of India in 1906. The Indian Mathematical Society was founded in 1907 in Poona as the Indian Mathematical Club. This was followed by the Institution of Engineers (India) in 1921, with its headquarters in Calcutta, but with branches at several other important cities. The Indian Botanical Society, with a peripatetic headquarters, but publishing its journal in Lucknow, was founded in 1921; the Indian Chemical Society, and the Geological, Mining, and Metallurgical Society of India, both with headquarters in Calcutta, were founded in 1924; whilst in 1934 three other all-India societies, also with their headquarters in Calcutta, were founded, namely the Indian Physical Society, the Indian Society of Soil Science, and the Indian Physiological Society. Other societies are the Society of Biological Chemists founded in Bangalore and the Institute of Chemists (India) founded in Calcutta in 1927.

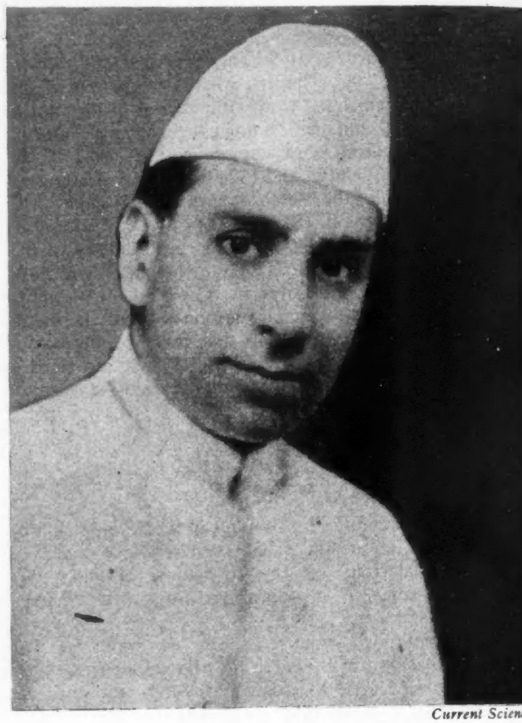
Whence come all the scientists to support this sudden efflorescence of specialist societies? The various Government services and research institutes provide a portion of the members, as also do the engineering and medical professions. But a very considerable portion of the members come from *the Universities*. The oldest universities in India are those of Bombay, Calcutta, and Madras, all founded in 1857, followed by the University of the Punjab in 1882, and the University of Allahabad in 1887. In addition during the present century a considerable number of additional universities have been founded. In these universities chairs of Mathematics, Chemistry and Physics are almost universal, and in addition most universities have chairs of Botany and Zoology, but only a small proportion a chair of Geology. Some of these universities have now been provided with splendidly equipped laboratories, so that from the staff and postgraduate students there is an increasing flow of research results: and official services and research institutes are no longer almost the only sources of original discovery. The consequence is that the official journals, though frequently giving hospitality to workers at universities and elsewhere, are no longer adequate to meet the needs of the whole of India's scientists. The required outlet is, of course, now provided by the journals of the many specialist scientific societies enumerated above.

Counteracting Isolation of Scientists

With this multitude of new bodies—services, societies, universities, research institutes—coming continuously into being, there has been a tendency towards greater specialisation and consequent *isolation of workers*. This has led to an increasing need for organizations directed to countering these fissiparous tendencies so as to bring men of science and other branches of learning back to a common fold and provide for a free change of views. This opportunity has, of course, continued to exist in the Asiatic Society of Bengal; but this Society cannot, of course, provide for the personal needs of scientists all over India. The isolation of scientific workers referred to above is not only the *specialist isolation* of many scientists one from another due to their specialization, but also the *geographical isolation* due to the large size of India, which it should be realized is roughly equivalent in size to Europe without Russia. If Britain has needed the British Association, what must be the needs of India in this respect? This need has been met by the formation of the *Indian Science Congress* under the aegis of the Asiatic Society, the inaugural meeting being held in Calcutta in 1914. Professors J. L. Simonsen of Madras and P. S. MacMahon of Lucknow were the moving spirits in this advance. The

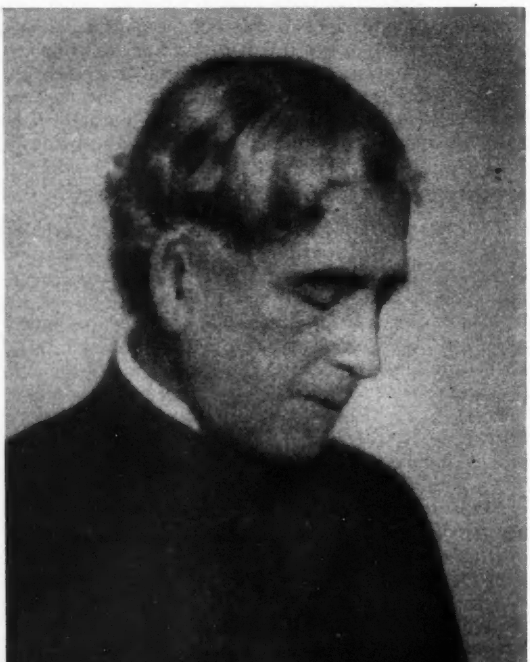
Science and Culture

FIG 6.—Professor M. N. Saha, D.Sc., F.R.S.



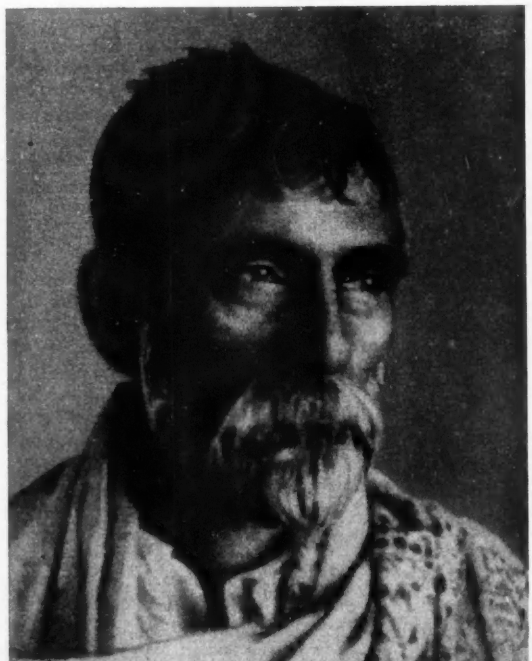
Current Science

FIG 7.—Professor D. Sahni, D.Sc., F.R.S.



Science and Culture

FIG. 8.—The late Sir Jagadis Chandra Bose, D.Sc., F.R.S.



Science and Culture

FIG. 9.—Sir Prafulla Chandra Ray, D.Sc.

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enterprise has succeeded beyond all expectation. The Congress moves from city to city annually as does the British Association, and is usually attended by over 1,000 scientists. In 1938 the Science Congress celebrated its 25th birthday, and was attended by a special delegation of the British Association from England. The sudden and lamented death of Lord Rutherford prevented him from presiding over this 25th session as had been intended, but his place was taken by Sir James Jeans. A special Silver Jubilee volume published by the Indian Science Congress Association[1] summarises in eighteen chapters, each by a specialist author, progress during this period in the various branches, including applied science.

Monthly Scientific Journals

The Indian Science Congress, itself the offspring of the Asiatic Society of Bengal, has been responsible for two further developments. One is the initiation of scientific journalism in India by the founding at the Congress session in Bangalore in 1932 of a monthly journal, *Current Science*, which is published in Bangalore, and may be regarded as the Indian equivalent of *Nature*. This was followed in 1935 by the founding in Calcutta of a second monthly scientific journal, *Science and Culture*, which may perhaps be regarded as the Indian equivalent of the English monthly journal *Knowledge*, the forerunner of *Discovery*, both in its larger format, and in catering in part for the general public as well as for the scientist.

Academies and the National Institute

The old-established Asiatic Society of Bengal was until recently the only body of Academy scope in India; but in 1930 the United Provinces Academy of Sciences was formed at Allahabad, with an all-India scope, but intended primarily to cater for all branches of science in Northern India. It was renamed the National Academy of Sciences, India, in 1936. A third society of similar rank the Indian Academy of Sciences, and also of all-India scope, was founded at Bangalore in 1934; this Academy provides in its *Proceedings* a valuable medium for the speedy publication of papers.

The second development from the activities of the Indian Science Congress was the foundation in 1935 of the National Institute of Sciences of India. This Institute was founded not to compete with any of the three societies of academy rank mentioned above, but to co-ordinate the work of various scientific societies, institutions, and Government Scientific Services and Departments throughout the country. This Institute has a limited Fellowship, to which an equally limited number of scientists is elected each year, on lines analogous to those followed by the Royal Society of London. Liaison is maintained with the three societies of Academy rank by representation of each of these bodies on the Council of the National Institute. One of the objects of this Institute is to act as a body of scientists of eminence for the promotion of the interests of science in India, and for representing internationally the scientific work of India. Another activity of the National Institute is to promote the holding of symposia for the discussion of selected problems of wide interest. Several such symposia have already been held on such subjects as the ionosphere, nitrogen supply to Indian soils, malaria problems in India, coal, and weather prediction. The National Institute also publishes annually *Indian Scientific Abstracts*, classified according to sciences.

It is hoped that with the existence of the Academies, the National Institute of Sciences, and the Indian Science Congress, as well as the publication of the two scientific journals mentioned, sufficient action has now been taken to counteract the undue effects of isolation due both to specialization and to geographical position.

Notable Scientists

Until the end of the nineteenth century the great majority of the research workers in India were Europeans; but with the subsequent greatly increased facilities for training in universities and research institutes in India supplemented by scholarships abroad, the progressive Indianization of the scientific services has become feasible. Our Indian friends are showing themselves to be amply endowed with the character and ability suitable for original research, as is indicated by the growing number elected to Fellowship of the Royal Society of London. In order of election these Indian Fellows now number six, and are Sir C. V. Raman (physicist), Professor Meghnad Saha (physicist), Professor Birbal Sahni (botanist), Professor K. S. Krishnan (physicist), Dr. H. J. Bhabha (physicist), and Sir Shanti S. Bhatnagar (chemist).

In addition we may mention two notable deceased Indian Fellows of the Royal Society. One is S. Ramanujan of Madras, a self-taught mathematician and genius who was elected to the Royal Society at the age of 31 and died two years later in 1920. Most of his work was connected with the Theory of Numbers, and, according to Professor G. H. Hardy "in some ways he is the most remarkable mathematician I have ever known". The other is Sir Jagadis Chander Bose, physicist and botanist. Early in his scientific career, by the aid of an ingenious instrument of his own device, he studied the properties of the Hertzian waves used in wireless telegraphy. He then turned his instrumental ingenuity to the study of the growth and movement of plants, and founded in Calcutta the famous Bose Research Institute, using his life's savings. Bose died at the age of 78 in 1937, but his Institute endures.

Also we must mention Sir Prafulla Chandra Ray, the doyen of Indian scientists, who celebrated his 80th birthday in 1941. Ray is a chemist who has lit the path of industrial chemistry to his fellow countrymen by founding near Calcutta the very successful commercial venture known as the Bengal Chemical and Pharmaceutical Works, Ltd. He is also the author of the *History of Hindu Chemistry*", quoted in the first part of this article.

That European scientists who have worked in India have set a high standard is shown by the fact that there are now living no less than fifteen Fellows of the Royal Society whose main life work was done in India. These comprise three geologists, three medical men, two geodesists, two meteorologists, two zoologists, one chemist, one botanist, and one astronomer. Whereas fourteen of these Fellows were in Government scientific services, including the Indian Medical Service, no less

[1] *The Progress of Science in India during the past Twenty-five Years*, edited by Dr. Baini Prasad, Calcutta (1938).

than five of the six Indian Fellows are in the employ of universities or research institutes. This indicates the quality of the additions to facilities for research in India now provided by the laboratories of these institutions.

Notable Discoveries

At this point we may ask whether, with this impressive and growing provision for scientific research in India, any notable discoveries can be credited to India, irrespective of the race of the discoverer. In the first place we must note that the scientific services have contributed greatly to the world's corpus of scientific knowledge by their trigonometrical, geodetic, and geological surveys, their study of earthquakes and of the weather, and of the fauna and flora of the Indian sub-continent and the surrounding seas, and by their study and conquest of tropical diseases, often with contributions by non-official workers. Outstanding amongst the service contributions are the topographical maps of India, which challenge comparison with those of any other country in the world. Special mention must be made of the new series of maps on the scale of one inch to the mile with their 50-foot contours; and of the Forest Survey maps on the scale of 4 inches to the mile, with their 10-foot contours, of Government reserved forests—maps that are a delight to all who have occasion to work in the forests.

A few special discoveries may be mentioned separately. The first is the discovery by Archdeacon Pratt of Calcutta, in 1855, from mathematical investigation of observations on the deflection of the plumb line made by officers of the Trigonometrical Survey of India, that the attraction exerted by the Himalaya Mountains was less than was expected on the basis of the visible mass of these mountains. Upon this discovery is really based the modern *theory of isostasy*, in accordance with which the high mountains have roots of lesser density than the rocks underlying adjoining plains and ocean basins, so that sufficiently wide columns of the earth's crust measured from the level of compensation, taken as about 60 kilometres below sea level, all weigh the same down to this level irrespective of whether they are higher columns capped by high mountains, or lower columns capped by plains or oceans. Departures from a state of perfect isostatic balance are regarded as isostatic anomalies.

A second notable contribution is that of Mr. R. D. Oldham, of the Geological Survey of India based on his studies of Indian *earthquakes*. All over the world earthquake shocks are recorded on seismographs in which are shown, on a moving roll of paper, the vibrations thus set up in the earth's crust often by a shock occurring thousands of miles away. It was Oldham who in 1900 succeeded in distinguishing in these records the vibrations produced by three types of waves, namely the longitudinal and transverse waves that pass direct along a chord through the earth's crust from the earthquake focus to the recording station, and the waves that travel via the surface from the focus to the recording station. Oldham had thereby discovered the key to the investigation of the interior of the earth and the identification of the depths at which lay the various shells of which the earth is now known to be composed.

The third notable discovery was made some 90 years ago by Dr. W. T. Blanford, also of the Geological Survey of India, destined to achieve fame both as geologist and zoologist. Whilst surveying in Orissa to the south-west of Calcutta, Blanford found a peculiar boulder bed composed of rounded boulders and pebbles, often of large size, set in a very fine-grained shaley matrix. This association was difficult to explain, because a stream strong enough to transport and deposit these boulders would wash away all fine silt. Although working in a hot tropical climate Blanford conceived the idea of transport by ice. This view has been found to be the correct one, and Blanford must be credited with the discovery in the tropics of relics of an ancient ice age. Similar rocks have also been found in South Africa, Australia, South America, and Australia, leading to the hypothesis of a former great southern continent, *Gondwanaland*. Discussion of the means by which Gondwanaland has been been broken up has led to the hypothesis of continental drift, supported by many geologists.

A fourth notable discovery has arisen from experimental investigation on the scattering of light started in Calcutta in 1919 by Sir C. V. Raman, leading to the discovery by Raman and K. S. Krishnan in 1928 of what has since been called the *Raman effect*. In 1922 Raman put forward a new theory to explain the colour of the sea, which was formerly supposed to be due to the reflection of blue sky light or to suspended matter. According to the new theory the colour is due to the molecular scattering of light. In the experimental investigations on light-scattering carried out by Raman and his co-workers between 1919 and 1927 various hypotheses were tested, that of Raman and K. S. Krishnan (1928), which assumed an anisotropic polarisation field, seeming the most satisfactory. These researches led to the discovery by Raman and Krishnan of a new kind of secondary radiation of modified wavelength, the discovery being announced on the 29th February 1928. This discovery, made in the laboratories of the Indian Association for the Cultivation of Science, has led to a vast volume of research on the Raman spectra of gases, liquids, and crystals, both in many of the laboratories of India and elsewhere.

The fifth notable discovery that we can mention here resulted from the study by Professor M. N. Saha of Calcutta, of ionisation in the chromosphere of the sun (1920), leading to an explanation, in terms of the ionisation theory, of the *ordered sequence of the spectra of the stars*, which Sir Norman Lockyer had previously tried to explain from a theory of evolution of elements. Sir Arthur Eddington, in the *Encyclopaedia Britannica* (14th edition) designates Saha's theory as one of the ten outstanding discoveries in astronomy and astrophysics since the discovery of the telescope by Galileo in 1608.

The sixth notable discovery is a medical one, namely that made by Sir Ronald Ross, of the Indian Medical Service, in Calcutta in 1898, *e.g.*, that the *malaria parasite* spends a part of its life in the mosquito, from which it is conveyed to the blood stream of man by means of mosquito bites. Not only has this discovery led to an enormous amount of valuable research on various aspects of malaria; but knowledge of the method of transmission of the disease has been followed by the widespread and successful introduction of preventive methods, and a resultant transformation of conditions of life in many tropical regions, and the saving of millions of lives.

For a general account of the numerous researches in all branches of science, pure and applied, including those mentioned above, conducted in India of recent years, reference should be made to the Silver Jubilee volume published by the Indian Science Congress Association, and already referred to in the first part of this article. In this will be found accounts of discoveries not only in the sciences mentioned for notable discoveries above, but also in chemistry, botany, zoology, anthropology and physiology, and in the applied sciences, agriculture, animal husbandry, forestry, engineering, and medicine.

Applied Research in India

In this brief story of the development of science in India emphasis has been, on the whole, laid on scientific research as such. But modern research is often directed to utilitarian ends. Most of the Government research institutes already enumerated have been set up for this purpose, and much good work has been done therein in agriculture, including plant breeding,[1] and in animal husbandry, forestry, irrigation, and medicine.

In addition research laboratories have been established or financed by private enterprise, such as the Laboratory of the Indian Tea Association in Assam, and the Technological Laboratories in Bombay supported by the Indian Central Cotton Committee, and in Calcutta and Dacca by the Indian Central Jute Committee; and such as the research laboratory of the Tata Iron and Steel Co., Ltd. Messrs. Steel Bros., on behalf of the Attock Oil Co., Ltd., have financed research for the ten years ending 1944 in the Chemical Department of the University of Lahore under the guidance of Sir Shanti S. Bhatnagar, into problems connected with the petroleum industry.

But on the whole there has been no organized attempt until recently to co-ordinate and stimulate the useful industrial research that might be carried out in University laboratories by university staffs. War conditions have caused this omission to be rectified; for in 1940 the Government of India formed a Board of Scientific and Industrial Research with Sir Shanti Bhatnagar as Director. We shall not know until after the war the extent to which this Board has been successful in co-ordinating and stimulating industrial research in India.

[1] Of which the most spectacular is the production at the Sugarcane Breeding Station, Coimbatore, Southern India, of new varieties of sugar cane now widely known throughout all countries where sugar cane is grown.

SUPERSONICS—*continued from p. 249*

Furthermore, this anomaly is accompanied by a change in the velocity of sound, though not so marked as in carbon dioxide. Evidently the water vapour molecules have the faculty to confer relaxation or dispersive power—what you will—on the oxygen, but again, the mechanism by which this occurs is as yet imperfectly comprehended.

Propagation of Liquids

Investigations with similar apparatus to that used for gases have been carried out in liquids. Herein it has been possible to pursue the measurements, though with less accuracy, it is true—to higher frequencies. Some investigators have reported results at the uncommon frequency of 80 million cycle/sec. The principal difficulty in liquids has been to get adequate energy into them, owing to their high density and, in a number of cases, large viscous damping. The latter impediment results in warming the liquid and, if care is not taken to remove the heat as it is formed, uncertainty in the temperature to which the results apply.

Up to the present a variation of velocity with frequency in liquids has not been established with certainty, but it has been shown that in some liquids the absorption of supersonic energy is far greater than one would expect if it were merely due to the usual frictional losses. Again, these anomalous liquids are those which, like benzene, scatter light most strongly and, in fact, are taken as typical for demonstrations of optical phenomena like the Raman effect.

In short, it appears that with improved technique and the exploration of a still higher range of frequency, information about molecular structure may be derived with the aid of this new tool similar to that which in recent years has been gained by the aid of light and the spectrometer. It is not likely, however, that comparable accuracy will soon be attained in sound; it is rather as a handmaid to spectroscopy than as a collaborator on equal terms that supersonics can garner useful data on the structure of molecules.

SIR RICHARD GREGORY, F.R.S.

The Editor, "Discovery"

Sir.—I much appreciate the compliment paid to me by the publication in your July issue of my early life and later associations with scientific work and interests. One or two points in the article may, however, lead to misunderstandings, to which I hope you will be able to direct attention in your next issue.

It is suggested that I was apprenticed to "cobbling" in a boot factory and that "it was not long" before I found myself a more congenial occupation as laboratory assistant at Clifton College. What I was really apprenticed to was "clicking", or the cutting out of the uppers of boots and shoes, which is a branch of the trade similar to that of the cutters in tailoring and is not to be confused with the mending of shoes or clumsy workmanship in the sense in which the word is now commonly employed. Moreover, I served more than four years in a factory and it was through studies before and after working hours and in evening classes that I came under the notice of the headmaster of Clifton College, The Rev. J. M. Wilson, who offered me a minor post at the College to enable me to continue them under better conditions.

After about three years at Clifton, I was selected, as the result of the May Examinations of the Science and Art Department, to be a Science Teacher in Training at the Normal School of Science, now part of the Imperial College at South Kensington. I took Part I of the Physics Course under Professor Guthrie and completed Parts II and III under Sir Arthur Rucker, and I was happily engaged all the time. During the year under Rucker, I and another fellow student read a short paper to the Physical Society. A wrong impression is, therefore, conveyed by the words that I "did not enjoy the physics curriculum" and "took the first possible chance of leaving College."

What happened was that though I was appointed for a further year at the College as a Science Teacher in Training, I was offered a temporary post at Portsmouth Dockyard School during the vacation and for economic reasons I decided to remain in it at a salary instead of returning to College to live on the allowance of a guinea a week during term time. I am, however, proud to have been a member of the College though I did not complete the full course for the Associateship.

Very truly yours,

R. A. GREGORY.

[*We apologise both to Sir Richard Gregory and to the author of the article for these "misunderstandings", which were due to the non-correction of a proof.*—EDITOR.]

Far and Near

Microfilm Reproduction in the War

WITH the wartime need to speed the transmission of information, microfilm is coming into its own. Its use has been brought to the notice of the general public through the introduction of the airgraph service. By the same method the British Army is able to collect in England photographed copies of the pay sheets of units serving overseas with a delay of only a few weeks. The world of science is finding microfilm very useful as a means of economically duplicating research papers; at least one commercial firm in the United States provides a microfilm "book" service of scientific literature. Microfilm is also being used to relieve the acute shortage of current scientific journals and papers in China, microfilm copies being flown there by plane, whereas it would be far more difficult to send the original printed material by air owing tot he cargo space it would waste.

From Russia, by cable to *Discovery* comes the following interesting story about microfilm. A prominent Soviet surgeon had devised a new surgical technique for use on the battlefield. To print an account of his method and distribute it would have meant a serious delay. The problem of making the information available to field hospitals as rapidly as possible was solved by a microfilm apparatus designed by Professor Alexander Visental, of the State Institute of Cinematography. With this apparatus the most important parts of the surgeon's report was photographed on microfilm and flown to the front where it could be enlarged on an ordinary lantern screen so enabling surgeons at field hospitals to become acquainted with the latest technique. The convenience of this method may be judged from the fact that 110 pages of typescript were recorded on a strip of microfilm small enough to be contained in a matchbox. Photographing 300 pages, including numerous drawings, takes only 90 minutes by this method.

Personal Notes

DR. E. F. ARMSTRONG has been elected president of the Royal Society of Arts.

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H. G. WELLS and DR. F. W. LANCHESTER, both "old boys" of Imperial College of Science and Technology, have been elected fellows of the college. Dr. Lanchester, a fellow student of both H. G. Wells and Sir Richard Gregory, designed the first British petrol automobile in 1895-6.

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Honorary membership of the Franklin Institute and the Franklin Medal have been awarded to DR. HAROLD C. UREY, professor of chemistry in Columbia University, for his discovery and production of heavy hydrogen.

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The Charles Chree Medal of the Physical Society was presented to BRIGADIER BASIL F. J. SCHONLAND, director of the Bernard Price Institute of Geophysics, Johannesburg, at the Royal Institution on July 16, when he delivered the Charles Chree lecture on "Thunderstorms and their Electrical Effects".

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The Harben Gold Medal of the Royal Institute of Public Health and Hygiene has been awarded to SIR HENRY DALE, president of the Royal Society. In his speech on the occasion when he was presented with it, Sir Henry referred to the distinguished Harben medallists who had preceded him, beginning with Pasteur and including Lister, Koch, Metchnikoff, Gorgas, Baron Kitasato, Sir Ronald Ross, and Sir Leonard Hill.

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New president of the Society of Chemical Industry is a Canadian-born American, Mr. WALLACE P. COHOE. The society's medallist is Dr. Leslie H. Lampitt, director of the laboratories of J. Lyons & Co. Ltd. and world-famous food chemist.

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Moscow Radio reports the award by the Soviet Government of the Stalin Prize, first class, and a cash prize of 150,000 roubles to Professor Ramzin for the invention of a new type of boiler. He is also awarded the Order of Lenin. High awards are given to a number of members of the staff of his institute, including a woman, for boiler construction.

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Ramzin was the leading figure in the Shakty Trial about 13 years ago of the Industrial party which conspired to overthrow the Soviet Government. He was sentenced to death but the sentence was commuted, and he continued his scientific work under surveillance.

£30,000 Bequest for Astronomy

MR. ROBERT CORMACK of Edinburgh, who died last year, left the residue of his estate, about £30,000, to the Royal Society of Edinburgh and the money will be used on the lines suggested by the late Astronomer Royal for Scotland, Professor R. A. Sampson, in research scholarships and popular lectures.

O.S.R.D. (U.S.A.) Director in England

DR. VANNEVAR BUSH, director of the U.S. Office of Scientific Research and Development, spent one afternoon of his flying visit to this country last month at the Royal Society, where he was given a reception by the fellows. At the Society's meeting before the Croonian lecture he was welcomed by the president, Sir Henry Dale, who described him as a scientist with wartime responsibilities "second to none in the whole world". Dr. Bush replied in a brief speech, saying how glad he was to have the opportunity of renewing old acquaintances. Referring to Anglo-American co-operation on scientific matters during the war, he remarked that it had presented problems no more difficult than those which occurred in the development of full collaboration between American institutions.

The Croonian Lecture

IN his Croonian lecture, Sir Edward Mellanby, described the role of Vitamins A and D—the "David and Jonathan" of the vitamins—in relation to bone growth and the nervous system. In 1918, when an experimental study of rickets was in progress, it was noticed that some of the animals developed severe inco-ordination of movement. When later it became possible to administer doses of vitamin A free from any vitamin D, it was found that this inco-ordination of movement in young animals was due to a deficiency of vitamin A. In such animals it was seen, when the tissues of the peripheral and central nervous system were examined under the microscope, that widespread degeneration of afferent nerves, both cranial and spinal, and of ascending fibres in the central nervous system had occurred.

It was suggested at this period that vitamin A deficiency had caused the degeneration in the nerve cells of the affected nerves, although this explanation was unsatisfactory as it was noted that those of the descending and efferent nerves were left intact. The investigations were then dropped for a time, but when they were resumed attention was concentrated upon the changes which occured in the labyrinthine capsules of the ear, it being obvious that the auditory nerve was particularly affected when vitamin A was deficient. Serial sections of the labyrinthine capsules were cut and examined under the microscope, and it was then discovered that bone developed by abnormal growth was clearly pressing on both divisions of the nerve to the ear. The investigations now came back to their starting point, namely bone development. Absence of vitamin A and carotene results in excessive bone development in certain positions, so that vitamin A apparently restrains bone production in some way. The delicate sculpturing of the bones in the animal body results from the fine equilibrium between the activity of the osteoblasts (cells which deposit bone) and the activity of the osteoclasts which remove it. As the skull developes it is necessary for its overall dimensions to increase, while the cavities of the skull must enlarge to accommodate the brain without constriction; it is the loss of activity among the osteoclasts in the absence of vitamin A which leads to the bone encroaching on the nervous system. Vitamin A has a similar effect on the growth of the vertebrae, which in its absence are more coarsely and clumsily moulded.

Bombs to kill Insects

A NEW type of "bomb" used by the U.S. Army in the Tropics is a 6-in. metal container charged with a new insecticide. The insecticide, developed by Dr. Lyle D. Goodhue of the U.S. Department of Agriculture, is discharged in the form

of a mist so fine that it remains suspended in the atmosphere and kills any bugs, flies, mosquitoes, ants, that it meets. One container is capable of fumigating 150,000 cu. feet, equivalent to the interiors of fifty giant bombers or 240 army tents. By killing disease-carrying insects, including the mosquitoes that carry malaria and yellow fever, the American Army hopes to reduce the casualty rates in regions where normally disease incapacitates more men than do bullets.

Army helping with Wood Pigeon Survey.

THE Army is collaborating with the investigation into the distribution of the wood pigeon being carried out by the Edward Grey Institute, Oxford. Under an "Army Nature Observation Scheme" standard record cards as used by the Wood Pigeon Investigation are being supplied to one of the army commands stationed in Britain through the unit education officers, who will periodically distribute, collect and return them to the accredited member of the Investigation. The soldier-observer may not of course give the address of his unit, and the cards have been modified accordingly. It is hoped that in this way every card will be self-contained and will serve as a guide *to the observer who is not yet a naturalist*. If the scheme shows promise of success in this command, it will be extended to others. *The Wood Pigeon Bulletin* comments: "The opportunity is so vast that it cannot be ignored. Thousands of men on lonely sites will receive an invitation to help to increase our fund of natural knowledge, an occupation which may leave them with a permament interest in natural history. Our duty as organisers of an investigation is to foster this interest by all means in our power and particularly by reporting new facts to those who have helped to discover them". The launching of this scheme recalls the recent presidential address to the Norfolk and Norwich Naturalists' Society in which Mr. Keith suggested that local natural history societies could play a more useful part by meeting the growing demand for more knowledge of wild life and natural history. The linking of the army's nature observation scheme with local natural history societies might well prove very fruitful.

Chinese Scientists at War

THE first despatches of Dr. Joseph Needham, member of the British Council scientific and cultural mission to China, have been published in *Nature* (July 3—10—17). He draws an inspiring picture of the way Chinese scientists are continuing their work despite the war. He describes the National Associated South-Western University, formed by the coalescence of three evacuated universities, Peiping, Chinghua and Nankai, in Kunming. He writes: "All the departments are housed in hutments built of mud brick, and roofed very simple with tiles or tin sheets . . . Inside, the floors are beaten earth, with a little cement, and extreme ingenuity has been used in fitting up laboratories for research and teaching. For example since no gas is available all heating has to be done with electricity, and hence when the supply of element wire for heaters—home-made out of clay—ran out some time ago, work was at a standstill until it was found that gun lathe shavings from one of the Yunnan arsenals would do very well. When haematoxylin became unobtainable it was found that dye, something very like it, could be obtained from an orange-coloured wood native to Yunnan, *Caesalpinai sappan*. When microscope slides could not be had, window panes broken by air raids were cut up and the unobtainable cover-slips were replaced by local mica . . . There are no air raid shelters and the population scatters to the hills if a raid looks like being serious. Built into the floors of each mud-brick building are large petrol drums, and all the most valuable apparatus is lowered into these when the siren goes, in order to preserve it against anything but a direct hit. Even in its humble buildings the Associated University has been bombed several times and many of the rows of huts destroyed".

Recently our London correspondent met two of the ten Chinese engineering and chemistry students who are guests in this country of the British Council. They were Mr. Loo Ti Li and Mr. Tsao Pung Hyi. Both started as students at the National Chingua University, and finally completed their courses at the university described by Dr. Needham. In November 1937, as the Japanese advanced, the university moved to Changsha, and in February of the following year it came to Kunming. All the students, our correspondent was told, completed the two long treks to evacuation areas on foot!

Aphids and Seed Potatoes

UNTIL recently the areas in which potatoes for seed could be grown in Britain were very restricted. English farmers were growing accustomed to the idea that they would always have to "import" seed potatoes from Ireland and Scotland. Now a "Seed-potato Growers Association," formed in the West of England in 1939, is operating with a large measure of success. It imported virus-free stocks from Eire, which were then planted, and the seed potatoes thus produced have been marketed. During the past two years not one complaint has been received from farmers about these English seed potatoes. The areas chosen for this experiment were selected by scientific methods. When deciding where seed potatoes shall be grown it is essential to consider the aphid population, for aphids—and in particular the species *Myzus persicae*—transmit virus diseases that affect potatoes.

In *Annals of Applied Biology* (May 1943, p. 33) L. N. Staniland describes the results of a five-year survey of the aphid population carried out in Devon and Cornwall. The important factors governing the migration and multiplication of aphids are temperature, humidity, and wind velocity. For instance, the winged *Myzus persicae* does not take to the air when the humidity is over 80% or when a wind of over four miles an hour is blowing; on the other hand, temperatures over 65°F favour flight. Low aphid populations are found at low altitudes approaching sea-level, where there is a high humidity and much exposure to winds. The findings of the Cornwall-Devon survey led to the conclusion that the west sides of Bodmin Moor and Exmoor where the humid coastal regions adjoin high exposed land with a high rainfall should theoretically be especially suitable for seed-potato production. Trial plantings have borne out this theory.

Earthworms and Soil

ADDED information on the subject of how worms improve soil fertility is afforded by recent tests made by Dr. L. C. Curtis of the Connecticut Experiment Station, New Haven, which show that worm casts contains plant food elements in greater quantity and in far more available form that that of the surrounding soil. Nitrate nitrogen, for example, is almost five times more abundant in the casts than in the top 6 inches of soil. Available phosphate is seven times greater, potash eleven times, and magnesium three times. Humus is about 40° greater than in the topsoil.

A Slug Census

GARDENERS with a bent for natural history will be interested to know some of the findings of Dr. H. F. Barnes and Mr. J. W. Weil of Rothamsted, who are studying slug populations. They have established, taking slugs collected after dark as a fair sample of the population, that different species of slugs reach their greater numbers at different seasons of the year. According to a note in *Monthly Science News* (June 1943), the Black Slug (*Arionater*) is most common in January although the greatest numbers of adults are present in August and September; the Dusky Slug (*Arion subfuscus*) reaches its peak about June; the Grey Field Slug (*Agriolimax reticulatus*) is most abundant about September; *Milax sowerbyi* and *Milax gracilis* (two of the keeled slugs) from September onwards; while *Arion hortensis* (the Garden Slug) is most common in November or December. Some species are found to be more sensitive than others to bad weather. The proportion of slugs of the different species in the total slug population may vary from gairden to garden. In the Harpenden area a typical population consists of roughly 62% *Milax gracilis*, 21% *Arion hortensis* and 62% *Agriolimax reticulatus*. Before giving the slugs they have captured their quietus, gardeners might care to add to our knowledge by computing the composition of the slug population in their own gardens. For their information, there are quite commonly 300,000 slugs per acre!

X-rays and Tuberculosis

SINCE the outbreak of war, the United States Public Health Service has given X-ray examinations for tuberculosis to nearly 250,000 people. With the 20 portable X-ray units in full operation, the Service should be able to complete 2,000,000 chest examinations this year.

Beer from Potatoes.

THE possibility of brewing beer from potatoes is being explored by the Ministry of Food from the point of view of saving grain. The Ministry, whose scientific advisers have consulted Professor R. H. Hopkins, Birmingham University's expert on brewing and industrial fermentation, as well as the scientists of a number of leading brewers, states that the proposal is still in the laboratory stage, but it appears that a small percentage of potatoes can be used in brewing certain types of beer.

Russian Rubber-dandelion in America

JANUARY issue of *Discovery* contained an account of trials being made with the Russian rubber-dandelion "Kok-saghyz" at Kew. The U.S. Department of Agriculture received supplies of kok-saghyz seeds from Russia by air last May, and according to Dr. Paul Kolachov, speaking at the recent Chemurgic Conference in Chicago, this has been distributed and is being grown with a considerable degree of success. He states that it can be grown in forty of the 48 States, whereas guayle and cryptostegia—two other plants containing rubber latex—are limited by soil and climatic conditions to the South-West and Florida-Gulf Coast regions respectively. Also kok-saghyz can be planted and harvested within one crop year, whereas guayule takes four in order to produce a substantial crop. The Americans are interested in by-products of the kok-saghyz crop too: the roots contain 12% inulin, and it is estimated that this would yield 250-lb. of glycol (per acre) for coversion into the butadiene used in the production of synthetic rubber.

SWEDEN, too, is developing this new source of rubber. By the end of next year Sweden will have available about 360 kilogrammes of seed, as well as a crop of about 27,000 kilos. of one-year old roots, and 38,000 kilos. of two-year roots. (Rubber content in the two types of root is 2% and 3% respectively). Australia has also planted a kok-saghyz crop.

The Rh Factor

CONSIDERABLE popular interest was aroused by the recent remarks of the Minister of Health about the Rh factor, an agglutinogen found in the human blood and taking its name from its presence also in the red blood cells of rhesus monkeys. He said that it had been discovered that 85% of the American and British white population had a factor in their red blood corpuscles which had previously gone unrecognised. For some years a particular kind of jaundice and anaemia had been known to occur in babies, and this condition seemed to run in families so that often there were several such babies in one family, some of whom were still born and others lived for only a short time. These jaundiced babies nearly always had the Rh factor in their red cells, whereas the mothers were negative. The babies became jaundiced and anaemic because before their birth the red cells of the baby had passed into the mother's circulation, where anti-bodies to the Rh factor had developed and passed back into the baby's blood, destroying the red corpuscles. If the baby was given a blood transfusion with Rh negative blood the anti-bodies were soon destroyed and the baby's life saved. The Emergency Blood Transfusion Service organised at the outbreak of war now supplied specially tested Rh negative blood to save the lives of those mothers and babies.

A useful account of the Rh factor was recently published by The blood transfusion committee of the Medical Research Committee in *The Determination of Blood Groups* (H.M.S.O. 4d).

Race, Class and Mating.

DR. C. D. DARLINGTON gave an interesting lecture in Cambridge last month upon this topical subject. Pointing out the differences between the New Testament and Darwinism approach to the question, he said that both were being applied politically. He explained how language groups, classes and other artificial barriers tended to produce inbreeding, and went on to discuss the relative merits and demerits of inbreeding and outbreeding. The Nazi race theory was struck a hefty blow.

British Scientists to equip Stalingrad Hospital Laboratory

BRITISH scientists are to raise the £3,500 needed to equip the laboratory of the new Stalingrad Hospital soon to be rebuilt. This announcement was made by the president of the Royal College of Surgeons, Sir Alfred Webb-Johnson, at a "Science for Victory" meeting on July 11 arranged by the A.Sc.W. to synchronise with a similar meeting held in Moscow.

Sir Robert Watson-Watt, A.Sc.W. president, the first speaker at the meeting, said that never before had the thread of scientific discovery, development, and application been woven so concientiously and with such success into the combined fabric of national and internat ional achievement. He described this thread as the very stuff of victory and declared that without it defeat would long since have overtaken us. To-day no military operation could be effective without the application of science, for which there was no "*ersatz*."

Professor J. D. Bernal, now attached to Combined Operations Command, contrasted the Nazis' use of pseudo-scientific theories of race with their deliberate policy of destroying scientific institutions in occupied territory.

Mr. J. G. CROWTHER, Director of the Science Department of the British Council, said that no moment could be more suitable than the present for British Scientists to express their solidarity with the scientists of the Soviet Union.

In a warmly acclaimed speech Prof. Sarkisov of the U.S.S.R. said: "I wish to extend my sincere and heartfelt thanks to all who are participating in the contributions and collections for the equipment of laboratories for the hospitals of heroic Stalingrad.

At the Moscow meeting Professor Koshkoyantz told the audience that Birkbeck college, where the London meeting was held, had been badly bombed, but the Germans had failed to break the British scientists' will to struggle. Academician N. Derzhavin, chairman of the Scientists' Anti-Fascist Committee, said that Soviet men of science grieved over the ruins of their own culture in the occupied areas, and also over the ruins caused by the Germans of the cultural monuments in Great Britain and in the occupied countries.

The Useful Guinea-Pig

IN a letter to *The Times* on 23 July, Professor A. V. Hill said that he wished to call attention to the public services of *Cavia cobaya*, the common cavy or guinea-pig. In the decade ending 1936 (he wrote) there were, in England and Wales, about 600,000 cases of diphtheria and about 30,000 deaths. That was before the Ministry of Health got to work with immunization. During those 10 years about 6,000,000 children passed through their susceptible age. One in 10 caught the disease, one in 200 died of it.

A high degree of immunity can be produced by two injections of a reagent prepared from diphtheria toxin by treatment with formalin and alum. This "alum-precipitated toxoid," or A.P.T., has lost its toxicity but kept its power of inducing immunity. It is prepared in batches each sufficient to treat 100,000 children. Objections are raised (a) that harm may be done by the injections; (b) that the immunity produced may not be effective; and (c) that experiments on animals are involved. As regards (a) there is no evidence at all that A.P.T. itself can do any harm, provided all proper precautions are taken in injecting it. As regards (b), the chance of contracting diphtheria is reduced at least 10 times, and the chance of death to almost nil, while if every child aged 1 to 15 were treated the disease would be virtually wiped out. As regards (c), guinea-pigs are the only animals employed, and the greatest number used for ensuring that a batch of A.P.T. is safe and effective is 20. Each guinea-pig receives two injections at a month's interval—just like a child. It suffers no inconvenience or pain. Ten days after the second injection it is bled —just like a human blood-donor—and its anti-toxin is determined.

Thus, 20 guinea-pigs allow 100,000 children to be immunized: 5,000 children to each guinea-pig. Of these 5,000 children, according to the statistics of the pre-immunization years, 500 would have contracted diphtheria, 25 would have died from it. Not bad work for one guinea-pig, saving the lives of 25 children! Especially when we remember that children are in very short supply, while a pair of guinea-pigs may have 40 descendants in a year. Surely a public expression of gratitude to *Cavia cobaya* is more sensible and patriotic than trying to stop children from being immunized against diphtheria.

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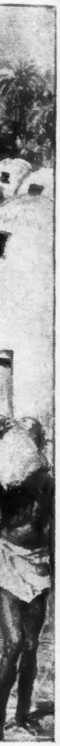

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